Analysis of the Impacts of Internet-based Business Activities on the Container Shipping Industry: The System Dynamics Modeling Approach with the Framework of Technological Evolution

By

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Submitted to the department of Ocean Engineering on March 13, 2003 in partial fulfillment of the requirements for the degree of Ph.D. in Ocean Systems Management at the Massachusetts Institute of Technology.

ABSTRACT

The internet-based business (e-business) activities have become a new technological challenge to the container shipping industry (CSI) in recent years. Despite the growing importance of e-business in the CSI, little systematic and theoretical research on e-business has been undertaken so far. This research therefore attempts to understand the potential impacts of e-business on the container shipping industry and to provide carriers with the managerial recommendations responding to the impacts of e-business.

An integrated system dynamics model is developed to simulate the potential impacts of e-business on the container shipping industry and to explore the successful managerial strategies for carriers with regard to e-business. In order to increase the confidence of the model, the general business dynamics in the CSI are reviewed and the historical impacts of new technologies on the container shipping industry are analyzed using the framework of technological evolution. Furthermore, the technology strategies of six different e-business models in the CSI are evaluated using the proposed three frameworks to identify the most promising e-business model.

The research finds that the profitability of carriers will be improved in the long term if they successfully develop the logistics service offering (LSO) with e-business in a cost efficient way. However, despite the improved profitability from the LSO and e-business, the container shipping service could be commoditized further unless changes are made to the current practice of expanding the containership capacity. In addition, the improved profits from the LSO and e-business will drive the structural changes in the container shipping industry. In order to improve the carriers' profitability over a long period of time, it is recommended that carriers continue to add new services on top of the container shipping service while expanding the containership capacity more wisely and conservatively.

Supervisor: Henry S. Marcus
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Undoubtedly, this dissertation should be dedicated to my extraordinary wife, Seungyeon. She has endured all the difficult times with me, and has encouraged me when I needed it most, while raising fantastically our precious kids, Elvina and "soon-to-be-born" baby. I am deeply grateful for her love, understanding, and encouragement – without which I cannot imagine finishing this daunting work.

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To Seungyeon, Elvina, and "Soon-to-be-Born" Baby

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Chapter 1 Introduction

1.1 Motivation and Purpose

The container shipping industry (called "CSI" hereafter), in which carriers transport containers having cargo inside from port to port, has been growing since its inception in the mid 1950s. Competing with traditional break bulk cargo shipping, in which cargo is shipped in the raw forms with different sizes and standards, the container shipping industry has expanded its market share due to its efficient, reliable, and timely service. During the developments of container shipping service, the CSI has experienced several technological evolutions posing new challenges, such as containerization, intermodalism, the double stack train system, EDI (Electronic Data Interchange), etc. The market participants in the CSI such as carriers, shippers, and intermediaries had to reinvent themselves to adopt the new technologies into their business operations.

Besides the historical evolutions of the technologies, the container shipping industry must deal with another technological challenge in recent years – the internet technology. The internet technology, which provides the low cost, flexible, and reliable telecommunication system, has started to impact the daily operations of business since the mid 1990s. Many small new ventures utilizing the benefits of internet technology have launched new business models to upgrade the current business operations in almost every industry. The container shipping industry was no exception to this new trend. More than 100 internet-based new ventures were founded in the container shipping industry, trying to establish new business models in this traditional industry. Even though some new ventures could not survive the sudden "bursting of the bubble of the stock market since the year of 2000, many internet-based new ventures are still operating and becoming an integral part of the container shipping industry. The internet-based business (called "e-business" hereafter) activities become a "must" that carriers, shippers, and intermediaries in the container shipping industry have to deal with. Particularly, carriers' business could be substantially influenced by the new e-business activities because many new ventures for the e-business have focused on close interactions with carriers.

Despite the growing importance of the e-business in the container shipping industry, very little research on e-business has been undertaken in the maritime research community, particularly in the academic research field. Only a few research projects have been performed to describe and classify the current e-business activities in the container shipping industry (Armstrong, 2000; Cargo Systems, 1999a, 1999b; Drewry Shipping Consultants, 2000; Stopford, 2000a, 2000b). Few systematic and theoretical analyses on the e-business activities in the container shipping industry have been published.

Part of the reasons for few research projects on the e-business in the container shipping industry is that the e-business activities have just started and have been an ongoing process; hence, it is hard to perform the academic or theoretical research. In particular, the empirical testing of managerial hypotheses is difficult due to the limited amount of data to be used for analysis.

Accordingly, this dissertation is motivated by both the strategic importance of the e-business and the difficulties of researching the e-business in the CSI. Even though it is hard to analyze the e-business in the CSI systematically, it is yet very critical to understand the potential impacts of e-business on the CSI and to develop the appropriate strategic measures responding to the challenges posed by e-business. In other words, the main purpose of this dissertation is to measure the impacts of this internet-based technological evolution on the CSI and to understand how to respond to any potential impacts.

Therefore, this dissertation tries to find the answers to two research questions:

- How could the e-business change the market dynamics in the container shipping industry?

- What are the successful strategies of carriers responding to the new e-business activities?

1.2 Methodology and Overview

Analyzing the impacts of e-business on any industry is not an easy task at this developmental stage of e-business because it is quite a recent phenomenon to amass the extensively reliable historical data. The container shipping industry, in particular, has been later in adopting the e-business activities than other industries so that research relying on the empirical data to investigate the impacts of e-business on the CSI may not be feasible.

Given the methodological difficulties of research on e-business in the CSI, this research adopts a computer simulation methodology to analyze e-business in the CSI. Since a computer simulation model could help users of the model easily implement the potential scenarios in a computer, familiarizing themselves with the dynamic situations of interest, and test the different strategies to cope with the potential challenges, the computer simulation methodology must be suitable for the research on e-business in the CSI. In other words, the computer simulation model for the impacts of e-business on the CSI can be a useful learning tool for the model users to be successful in responding to the new challenges posed by e-business activities.

Among the several computer simulation methodologies, a system dynamics modeling methodology is chosen for this research. System dynamics modeling is a computer simulation methodology that enhances the understanding of complex systems, which can be dynamic industry systems, engineering process systems, dynamic urban development systems, or corporate strategy development systems, using the causal relationships among the variables that substantially affect the systems performance. The methodology is particularly useful when the internal dynamics of a system are too complex to be described with other traditional mathematical modeling methodologies. In addition, the system dynamics methodology provides a flexible modeling tool so that it could effectively simulate managerial decisions of the system's participants. Since the internal dynamics of the container shipping industry is already very complex and many managerial decisions are involved with e-business activities, the system dynamics approach is very useful in explaining the relationships of industry variables and e-business variables.

In addition, in order to increase the confidence in the system dynamics model for analyzing the impacts of e-business on the CSI, a historical analysis of the technological impacts in the container shipping industry using the framework of technological evolution is also performed in this research. E-business itself cannot be separated from the ongoing technological evolutions in the container shipping industry. The characteristics of e-business in the CSI can be better understood within the context of "containerization," which is a major technological evolution in the maritime industry and helps form the container shipping industry itself. Containerization has undergone several technological evolutionary challenges such as intermodalism, double-stack train operation, and EDI connections, etc. After these evolutionary processes, the container shipping industry is now confronted with a new challenge: internet-based business activities. Therefore, it is valuable to analyze the internet-based business activities in the container shipping industry by applying the framework of technological evolution to the containerization context.

This historical analysis provides a broader perspective to understand the relationships between the e-business activities and the potential structural changes in the container shipping industry; hence, the outcome of this analysis is used as the inputs to the system dynamics model for the impacts of e-business on the CSI.

Furthermore, the e-business models in the container shipping industry are evaluated using three frameworks (which are described in later chapters) – the "Appropriability – Complementary Assets" (A-CA) framework, the "Network Externality – Customer Lock-in" (NE-CL) framework, and the "Market Type – Customer Focus" (MT-CF)" framework – developed from the perspective of technology strategy. This evaluation presents which e-business models are most likely to succeed based on their technology strategy. The results of this evaluation are also used as the inputs to the system dynamics modeling so that the most potentially successful e-business model is simulated for analyzing the potential impacts of e-business on the container shipping industry.

In summary, this dissertation can be divided into two parts: the technological evolutionary part (Chapter 2, 3, 4, and 5) and the system dynamics modeling part (Chapter 6, 7, 8, and 9). The technological evolutionary part first explains the general business dynamics in the container shipping industry deriving the strategic challenges of carriers (Chapter 2); analyzes the historical impacts of technological evolutions in the container shipping industry (Chapter 3); reviews the impacts of EDI, which is the most recent technological evolution in the CSI and is similar to the internet technology (Chapter 4); finally, delineates the characteristics of the e-business activities in the container shipping industry (Chapter 5). The technological evolutionary part provides the overall insights into the impacts of e-business on the container shipping industry and is used for the inputs to the system dynamics model in the second part.

Meanwhile, the system dynamics modeling part is composed of four chapters: Chapter 6 explains a model for the dynamics of supply-and-demand in the container shipping industry, which is used as a reference system to analyze the potential impacts of e-business on the CSI. Chapter 7 describes the model for the diffusion dynamics of EDI in the container shipping industry, which is used as a proxy for the potential diffusion of e-business in the CSI. Chapter 8 presents the system dynamics model for the potential impacts of e-business on the container shipping industry by synthesizing all analyses and models discussed in the previous chapters. Finally, the overall conclusions and managerial implications regarding e-business in the container shipping industry are provided in the Chapter 9.

To summarize, Figure 1-1 describes the methodology and overview used in this research.

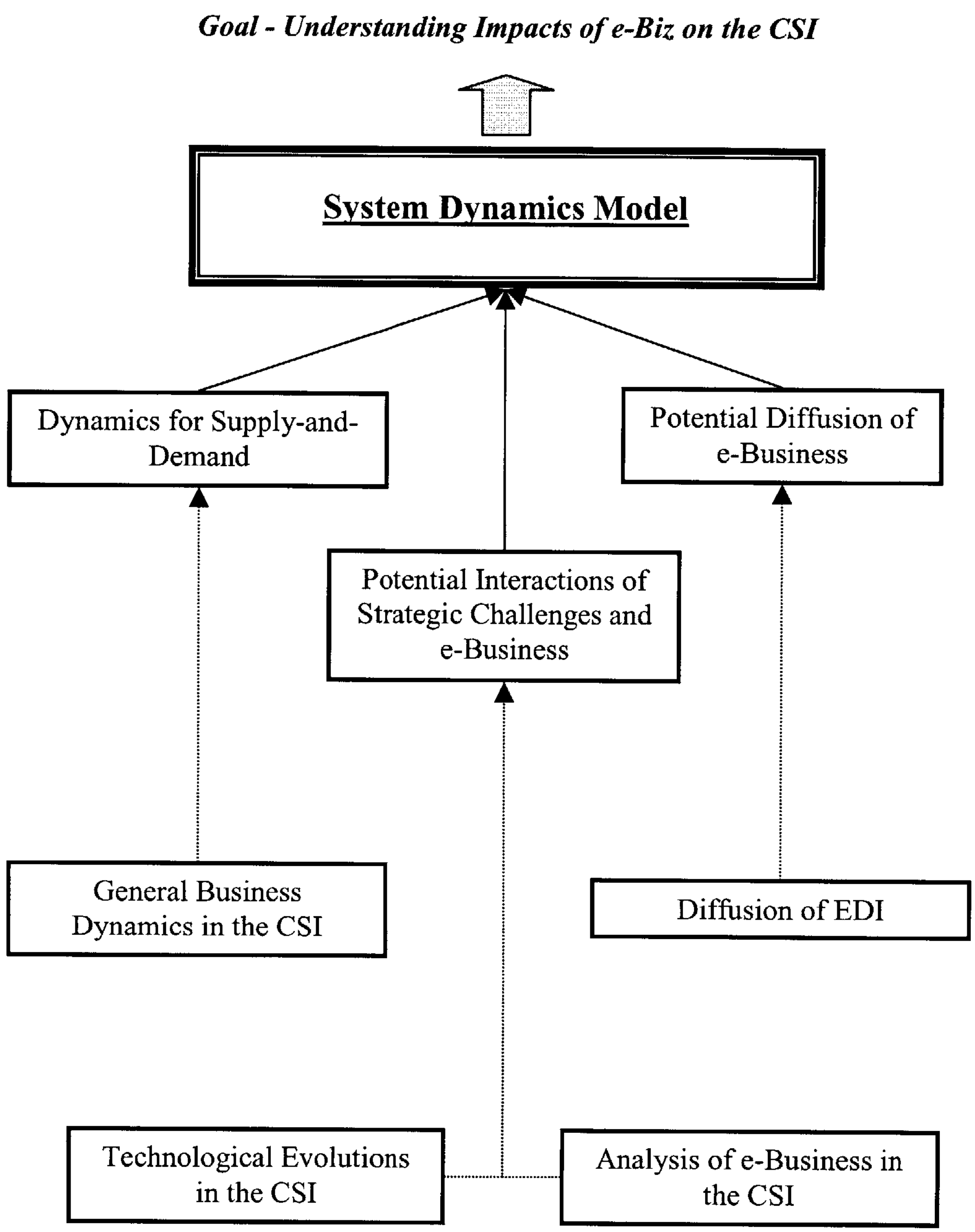


Figure 1-1 Research Methodology and Overview

1.3 Contributions

The work presented in this dissertation provides several contributions to the maritime research community.

First, this research proposes a methodology to analyze the impacts of a new technology on the industry by integrating the technological evolutionary framework and the system dynamics modeling methodology. Since research on the potential impacts of a new technology on the industry should investigate the future changes due to the technological impacts on the industry, the research could be subjective by nature as opposed to being objective. Unless the research adopts the rigorous methodologies, it cannot be regarded as an acceptable work in the research community. Despite the uncertain nature of the e-business research, the methodology adopted in this research presents a new approach how to analyze the potential impacts of e-business on the industry in a more rigorous way. This approach, therefore, can be extended to the research of analyzing the potential impacts of a new technology on any industry of interest.

Second, this research also proposes three frameworks for evaluating the success potential of the e-business models from the perspective of technology strategy. These frameworks are useful tools for anticipating the potential success of any technology-based new ventures. They can be applied to evaluate other e-business models in any industry.

Third, a system dynamics model for the dynamics of supply-and-demand in the container shipping industry is developed. Although it is based on the previous model for other industries (Weil, 1998), it is extensively updated to accommodate the industry-specific characteristics in the container shipping industry and is the first system dynamics model to simulate the container shipping industry. The model developed in this research can be used for other purposes relating to the container shipping industry, e.g., how to decrease the cyclicality of the container shipping business, etc.

Fourth, this research constructs a system dynamics model for investigating the impacts of e-business on the container shipping industry and, using the model, identifies the crucial managerial variables that should be carefully managed to respond to the potential impacts of e-business. Using this model, the managers in the container shipping industry could have better insights into how to effectively manage the new technological challenge – i.e., e-business activities.

Chapter 2 General Business Dynamics in the Container Shipping Industry

2.1 Introduction

This chapter explores general business trends of the CSI, focusing on ocean container movement. The discussion includes industry factors, key players, industry value chain, and key business drivers. Finally, strategic challenges of the CSI from the carriers' perspective are provided in the end. The information in this chapter serves as the starting point for further discussion on internet-based business strategy for the CSI.

2.2 Industry Factors

Five major factors have been dynamically affecting the CSI; world fleet and ports for supply, waterborne cargo for demand, technology for support, finance for purchase of capital resources, and policy and regulation for the overall framework.

World Fleet and Port works as a supply source for the CSI. It includes shipbuilding activities, ship capacities in the world, port facility capacity lifting on or off the containers, and intermodal connection facilities that transfer the containers from one transportation mode to another. Meanwhile, *Waterborne Cargo* serves as the demand role in the CSI, requesting container movement service from the carriers. The volume of waterborne cargo characterizes the demand and it is affected by the world trade patterns.

Technology, such as automated cargo handling system, internet, or wireless communication technology, provides the supporting roles that could make the industry process more efficient and reliable. The *Finance* community gives the monetary medium that expedites the ship procurement, protection and indemnity insurance. In general, these two factors are lubricants smoothing the container shipping industry processes.

Finally, *Policy and Regulation* rule the business framework throughout the CSI. Among the most noticeable regulations are the Ocean Shipping Reform Act (OSRA) and import/export regulations.

Although all the above factors are very important in understanding the industry dynamics of the CSI, the role of technology has been dramatically increased as in other industries. More specifically, recent applications of internet and wireless communication technology to the CSI have changed the industry pictures. This phenomenon evokes difficult strategic questions to the current players in the CSI.

2.3 Industry Players

Three different players are critical in the global container shipping business: *carriers* as sellers, *shippers* as buyers, and *intermediaries*. Each player has slightly different market interests, but basically has the same goal – optimizing its own role in the logistics value chain.

2.3.1 Carriers

In the carrier segment, the players include ocean carriers, port terminal operators, truckers, and railroad companies. Their primary job is to provide container transportation services for the shippers so that the containers move smoothly from shippers to the final consignees.

2.3.2 Shippers

Shippers, or owners of cargo, are the buyers of container transportation services. Although every company, which has to deliver its product to the customers, could be a shipper, the shippers are generally composed of manufacturing companies, large retailers, and shippers' associations, etc. The shippers market is so fragmented that no single large company can control the substantial portion of container capacity on a certain trade route.

Quite recently, shippers have become very aggressive in improving supply chain management with new technology, which provides serious innovation pressure to carriers. Given the era of borderless international business, logistics needs have been increasing over time and the efficient management of the supply chain is very important for firm-wide strategy setting. In addition, long and complex supply chains from the suppliers to the final customers provide numerous opportunities to be efficiently improved by innovative technologies. Even a small improvement of the supply chain may provide enormous cost savings and profitability gain to the shippers.

2.3.3 Intermediaries

Intermediaries perform a matching function by finding carriers for shippers and vice versa: for example, a coordinating function by arranging transportation service across different transportation modes; consolidating shipments for shippers; or customs clearance function. The intermediaries include freight forwarders, 3rd party logistics companies (3PLs), non-vessel-operating common carriers (NVOCCs), customs brokers, and so forth. Basically, they arrange and manage the movement of goods without owning the freight or the transportation equipment.

2.3.3.1 Freight Forwarders, NVOCCs

Freight forwarders arrange transportation services with ocean carriers on behalf of shippers, which could be one or more companies. They usually handle international cargo transported by containerships and cooperate with customs brokers to expedite the international container movements.

Meanwhile, the NVOCCs were originally container capacity resellers for ocean carriers; i.e. ocean carriers sell their extra capacity, which may not be marketed by them effectively, to the NVOCCs, and then the NVOCCs resell the container capacity to the shippers. The NVOCCs market themselves to the shippers as if they own real containerships by issuing bills of lading and publishing tariffs.

Although they started to target small shippers, which cannot receive favorable freight rates from the major container carriers because of the small freight volume, NVOCCs now try to market to the large shippers to directly compete with container carriers. Therefore, the container carriers have recently tried to give the NVOCCs less favorable rates than their largest customers receive.

Many of these freight forwarders and NVOCCs arrange door-to-door service for shippers, i.e. ocean transportation and inland transportation by truck or rail from the origin to the destination. Forwarders usually provide the necessary documentation for importing or exporting goods. Typically, they operate container depots and provide consolidation functions for less-than-container (LTC) load shipments.

2.3.3.2 Customs Brokers

Customs brokers are licensed by the US Department of Treasury to handle all types of international shipments. These brokers prepare customs entries, determine applicable customs tariff rates and shipment values, as well as file other necessary customs documentation. In addition to the Treasury, more than 40 other government agencies administer non-tariff requirements in the US. Customs brokers handle more than 90 percent of all US imports, and also often arrange the transportation service of these shipments (Boyle, 2000).

2.3.3.3 3rd Party Logistics Companies (3PL)

3PLs offer a wide range of services including warehousing, carrier management, dedicated fleet operations, distribution and inventory management. The 3PLs are marked by a high degree of integration with shippers' operations. They perform value-added activities such as packaging, setting up, and stocking retail store displays. In other words, their service offerings are not limited to arranging ocean-related transportation services for shippers.

During the 1990s, many shippers outsourced their transportation management functions to 3PLs; the industry growth rate for 1998 was 21 percent. Gross revenues for the 3PL industry grew by 15 percent to nearly $40 billion in 1998. Net profitability ranged from 5 to 7 percent (Armstrong, 1999). Armstrong (1999) observes that only half of the Fortune 500 companies are using 3PLs. His analysis of shippers indicates that major opportunities are available in companies of all sizes especially mid-sized and smaller companies.

2.4 Industry Value Chain

Porter (1980) has developed the value chain concept as a useful framework to analyze an industry. The value chain provides a structural view of the industry so that a market researcher can better understand the industry dynamics. There are two different value chains in the CSI: One is an 'asset management' value chain; the other is a 'service delivery' transaction-based value chain.

2.4.1 'Asset Management' Value Chain of the Container Shipping Industry

As shown in Figure 2-1, the 'asset management' value chain of the container shipping industry is composed of 6 activities: container service demand (CSD), transportation network planning (TNP), marketing sales and negotiation (MSN), contracting and documenting (CD), container movement (CM), and finally customer support (CS).

Each player in the market has provided valuable functions to the industry for each value chain. For example, the shippers play an important role in CSD, MSN, and CD value chain and the intermediaries provide values to the chains of MSN and CD. Unlike shippers and intermediaries, the carriers cover all the activities of value chain except CSD role. An interesting point from this 'asset management' value chain is that all three players participate in the MSN and CD activities. In other words, the MSN and CD activities are the most important functions in this industry and generate value-added service to the industry. This is why recent internet-based new companies try to penetrate these segments.

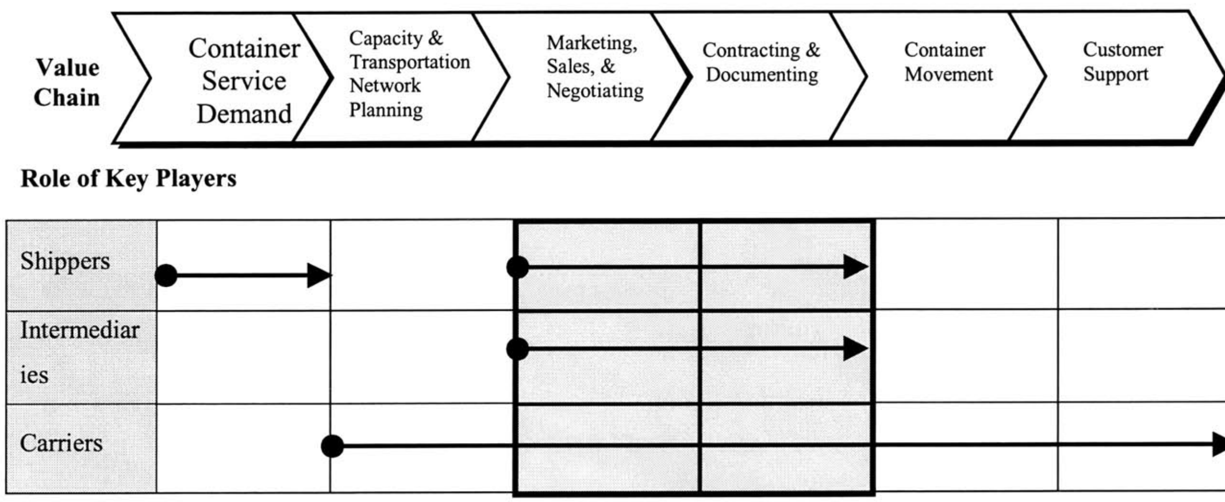


Figure 2-1 Value Chain of Container Shipping Industry – 'Asset Management' Perspective

2.4.2 'Service Delivery' Value Chain of the Container Shipping Industry

If we re-focus on the transaction processes between shippers, who buy the container shipping service, and carriers, who sell the container shipping service, the container shipping value chain in Figure 2-1 can be reconfigured as shown in Figure 2-2. The 'service delivery' value chain is composed of three steps between shippers and consignees: "processing market information," "negotiation for transportation service," and "transaction & movement."

The 'service delivery' value chain is very useful for analyzing internet-based business activities in the CSI. The internet-based businesses in the CSI have developed unique business functions with internet technology corresponding to each specific value chain activity. Those functions are "portal" for processing market information, "e-marketplace" for the negotiation for transportation service, and "Collaborative Tool Provider (CTP)" for the transaction & movement activity. The activities of internet-based business in the CSI will be explored in detail in the later chapters.

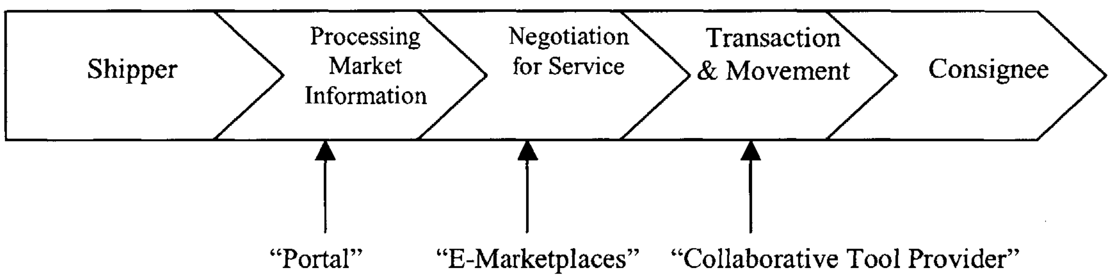


Figure 2-2 Value Chain of the Container Shipping Industry – 'Service Delivery' Perspective

2.5 Competitive Drivers of the Container Shipping Industry

Many factors drive the internal dynamics of the container shipping industry. Eight competitive drivers of the container shipping industry are identified to analyze the structural dynamics in the CSI. The drivers can be categorized into three types: demand-side drivers, supply-side drivers, and environmental drivers. Table 2-1 shows the complete list of drivers of the container shipping industry.

Table 2-1 Competitive Drivers of the Container Shipping Industry

Type of Competitive Drivers	List of Competitive Drivers
Demand-side Drivers	• Increasing Demand for Container Shipping Service • Increasing Demand for Logistics Service • Trade Imbalance and Empty Container Movements
Supply-side Drivers	• Chronic Overcapacity • Upsizing of the Containerships • Continuing Consolidation of Carriers
Environmental Drivers	• Deregulation • Technological Evolution

2.5.1 Demand-side Drivers

Three competitive drivers affect the demand side of the container shipping industry: Increasing demand for container shipping service, increasing demand for logistics service, and trade imbalance and empty container movements

2.5.1.1 Increasing demand for container shipping service

Demand for container shipping service has increased dramatically since the first container shipping service in 1956. Figure 2-3 reveals that the number of containers transported, measured by million TEUs of port handling, has substantially increased over time. On average, the container shipping service has grown at 10.3% per year from 1975 to 2000.

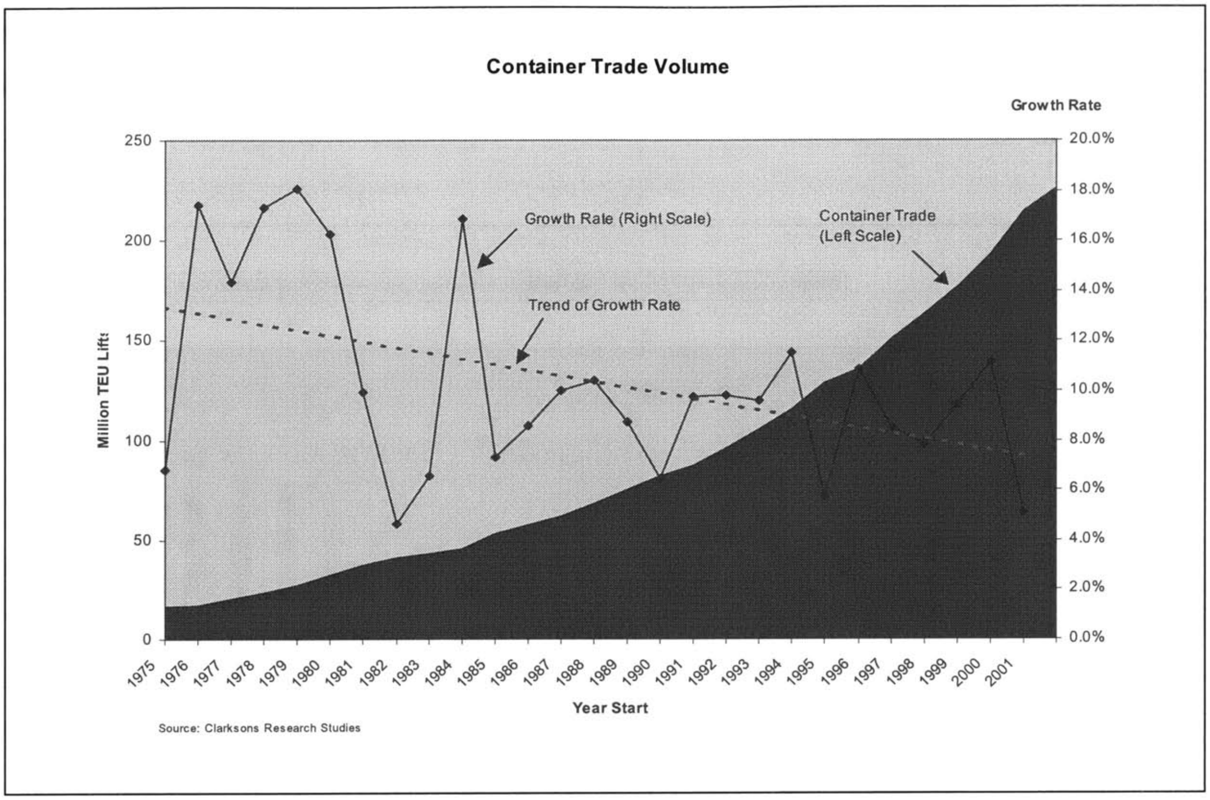


Figure 2-3 Number of Containers Transported over Time

Three factors might affect this phenomenal demand growth of the container shipping service. First, a global outsourcing strategy boosts the demand for container shipping service. In the 1980s and 1990s, many companies in the developed countries outsourced their manufacturing capabilities to the Asian manufacturers in order to utilize lower factor costs from the Asian countries. This outsourcing strategy decoupled the end consumers in the developed countries from the manufacturing sources. So the products manufactured in Asia should be transported to the developed regions such as Europe and the US via containerships.

Second, increasing containerization rate (CR) drove the increasing demand for container shipping service. Containerization rate, the ratio of the containerized cargo to total general cargo that could potentially be containerized, has increased historically, thereby driving the demand for container shipping service. Figure 2-4 shows that the CR has increased rapidly and reached around 50% of total general cargo in terms of weight in 1998.

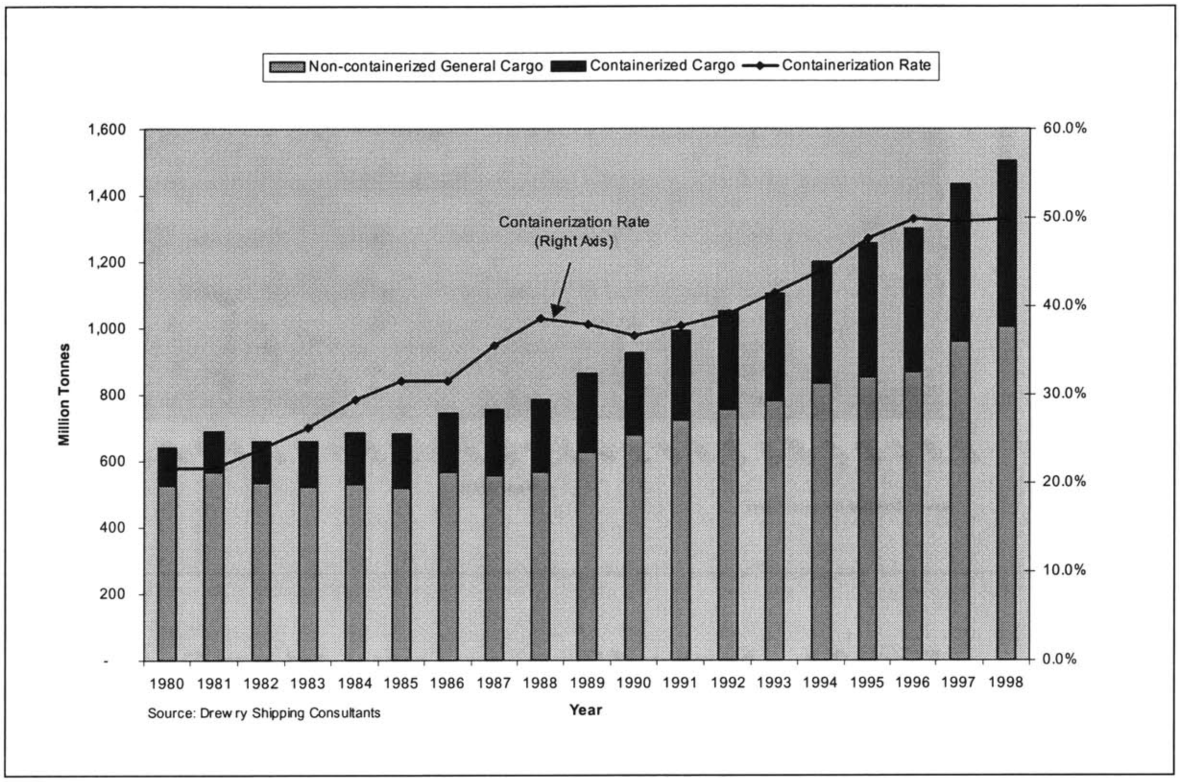


Figure 2-4 Historical Containerization Rate

Third, the international policy of free trade, which has been exemplified by the launch of WTO (World Trade Organization) and NAFTA (North America Free Trade Agreement), also spurred the demand for container shipping service. In other words, the policy of free trade lowered trade barriers such as customs, allowing low costs of shipping raw materials and final products, thereby attracting more demand for container shipping service.

This increasing demand for container shipping service presents a tough challenge for carriers. Although the increasing demand could provide ever-increasing revenue to carriers, they have to endure severe competition among themselves. Particularly, deploying the container shipping capacity on time to meet the increasing demand is critical to be successful. However, it turned out to be challenging for carriers to optimally procure the shipping capacity. In reality, carriers have always suffered overcapacity problems over time.

In addition, the increasing demand for container shipping service requires carriers to deal with increasing information overload. In order to deliver containers to the right destination on time, carriers should manage container-specific information efficiently. Otherwise, containers might be transported to wrong customers and carriers will lose the business. Accordingly, as the number of containers to be transported increases, carriers' capability of dealing with information overload becomes one of the important barometers of carriers' success.

2.5.1.2 Increasing Demand for Logistics Service

As global outsourcing strategy progressed, the supply chain of shippers became much longer, more international, and more complex. So shippers needed a more sophisticated system of logistics management. Rather than just moving containers from the contract manufacturers to the final customers, shippers need to manage advanced logistics functions such as shipment tracking, just-in-time (JIT) inventory management, collaborative planning, and management of international trade documents, etc.

An industry survey (Reeve, 2001) also confirmed this increasing demand for logistics service: Improving global supply chain management is one of top priorities of CEO's chief concerns over the next three to five years. In order to meet this demand, shippers started to outsource their logistical functions to the logistics-specialized companies, such as 3rd party logistics companies (3PLs).

Because the logistics-related service is not an asset-based, but an information-based business, the logistics service is more profitable than the traditional carriers' business – just moving containers from port to port. Realizing high profit margin potential from the demand for logistics service, several major carriers started to offer the logistics service through their subsidiaries. For example, American President Line (APL), a premier global container shipping company, launched the sophisticated logistics service through its subsidiary, APL Logistics. Therefore, this increasing demand for logistics service will be a competitive driver of the container shipping industry over the next several years to come.

2.5.1.3 Trade Imbalance and Empty Container Movements

As many Asian countries, such as China, Korea, Indonesia, Hong Kong, Singapore, Malaysia, etc., became sourcing partners of the developed regions (i.e., Europe and North America), severe trade imbalance occurred: The container volume transported from Asia to Europe and North America substantially outnumbered the container volume from Europe and North America to Asia. Particularly, the trade imbalance was exacerbated as the US economy was booming in the late 1990s. Figure 2-5 shows the development of container imbalances on main trade routes and the imbalances have increased over time.

The trade imbalance provoked the serious problem of empty containers in the container shipping industry. For example, because the number of containers eastbound in the transpacific trade route (i.e., from Asia to the US) is always larger than the number of containers westbound, carriers should reposition the large number of empty containers from the US to Asia. Figure 2-6 shows the development of global empty container throughputs. The empty containers have contributed on average 20% of total global container throughput.

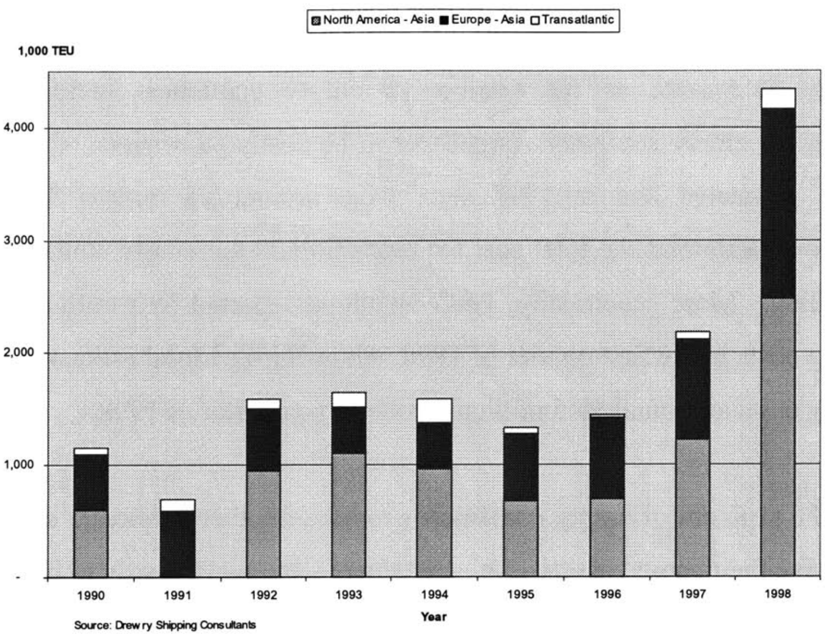


Figure 2-5 Evolution of Nominal Container Imbalances on Main East-West Trades

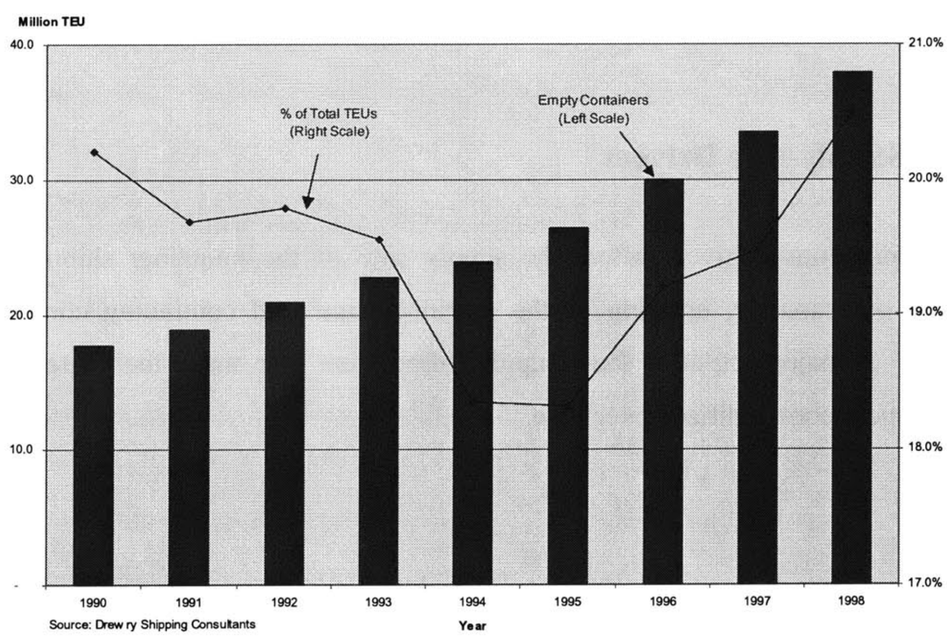


Figure 2-6 Development of Global Empty Container Throughput

Since the empty container movements are not revenue-generating, the profitability of carriers may deteriorate as the number of empty containers increases. In fact, repositioning the empty containers turned out to be costly to carriers. Drewry Shipping Consultants[1] estimated that in 1997 there were around 15 million TEUs of empty container movements and the total cost for repositioning the empty containers amounted to $10.5 billion. More specifically, P&O Nedlloyd reported $10 million in equipment repositioning costs in the first quarter of 1998, while Hapag Lloyd estimated its additional repositioning costs at around $5.5 million for the same quarter of 1998.

Therefore, the problem of empty containers provides another challenge to carriers: They have to manage their capital assets – i.e., containers – more efficiently to be successful. In order to reduce the cost of managing empty containers, carriers have tried to either collaborate with other carriers through alliances, lease more containers as opposed to buying them, or adopt new internet-based collaboration services[2] for exchanging empty containers. In any event, the trade imbalance and empty container movements will require carriers to be more efficient in asset management.

2.5.2 Supply-side Drivers

Three competitive drivers affect the supply side of the container shipping industry: chronic overcapacity, upsizing of the containerships, and continuing consolidation of carriers. A major output of these supply-side drivers is to make the container shipping service more commoditized over time.

[1] Drewry Shipping Consultants, (1999). "Container Market Outlook: High Risk & High Stakes: Where is the Payback?" p. 38.
[2] The providers of this service include Interbox.com and Synchronet.com

2.5.2.1 Chronic Overcapacity

The container shipping industry has suffered from chronic overcapacity problems. As illustrated in Figure 2-7, the containership fleet capacity (CFC) has increased relentlessly for the past 20 years. The CFC at the end of 2000 amounted to 4.8 million TEUs, which is around nine times more containership capacity than that of 1981. The year-over-year growth rate for the past two decades ranges from 5.0% to 18.6% and the average growth rate is around 10.4% per annum.

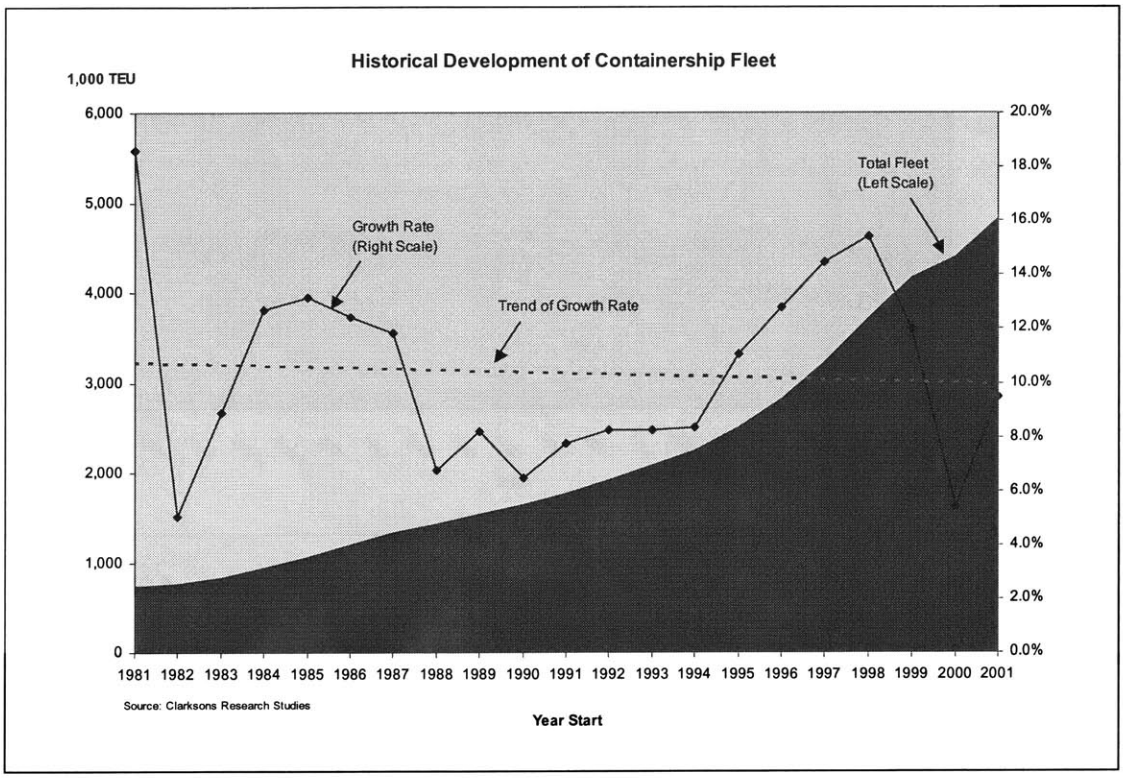


Figure 2-7 Containership Fleet Capacity over Time

In order to figure out the overcapacity situation in the container shipping industry, historical growth rates of demand and capacity of container shipping service are analyzed. Figure 2-8 shows that the linear trend of capacity growth rate for the past 20 years has always outnumbered the linear trend of demand growth rate. In other words, demand and supply of container shipping service have not been optimally balanced at all. There has always been some extra capacity that was not efficiently utilized. Hence, this figure confirms that the container shipping industry might have suffered from chronic overcapacity problem.

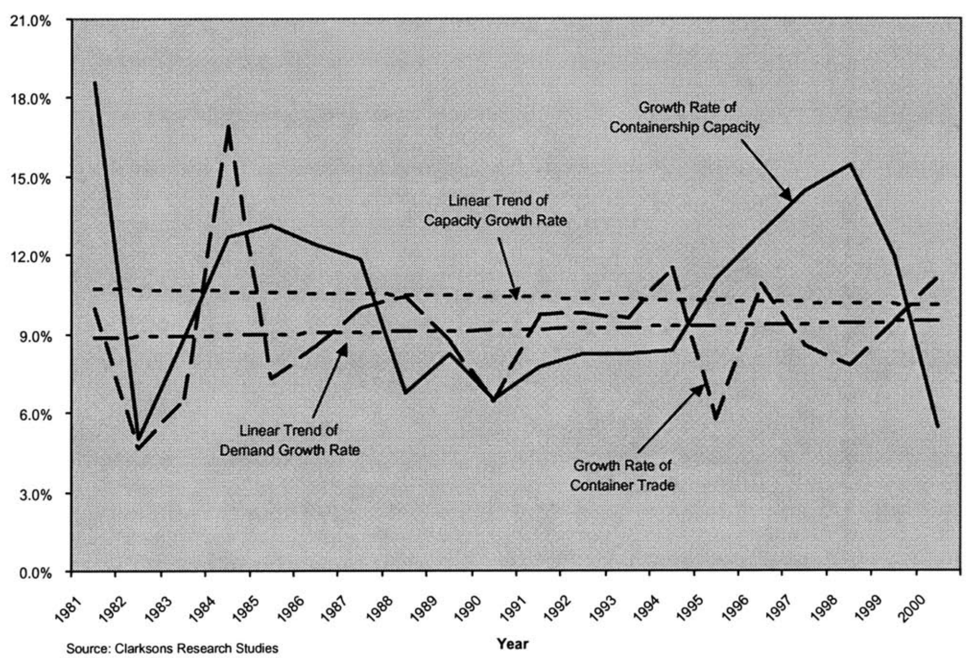


Figure 2-8 Comparison of Growth Rates of Demand and Capacity of Container Shipping

This chronic overcapacity has directly impacted on the freight rate of container shipping service: the freight rate has constantly decreased over time. For example, the freight rates in transpacific and transatlantic trades have been so tremendously eroded for the past two decades that freight rate in 1998 is on average 63% lower than that in 1978 in real dollar terms (Table 2-2). In addition, looking at the recent worldwide freight rates in the 1990s, Figure 2-9 also confirms the severe erosion of the freight rates.

Because of this lowered freight rates, carriers are confronted with low profitability despite the increasing demand for container shipping service. In other words, the container shipping service becomes a fairly commoditized business.

Table 2-2 Freight Rates in US East-West Trades - A 20 Year Perspective

(Change in average freight rates, 1978-1998)

		Nominal Terms	Real Terms
Transpacific	Eastbound	-32.1%	-72.1%
	Westbound	-20.8%	-67.5%
Transatlantic	Westbound	-4.6%	-60.9%
	Eastbound	+18.2%	-51.5%

(Source: Drewry Shipping Consultants)

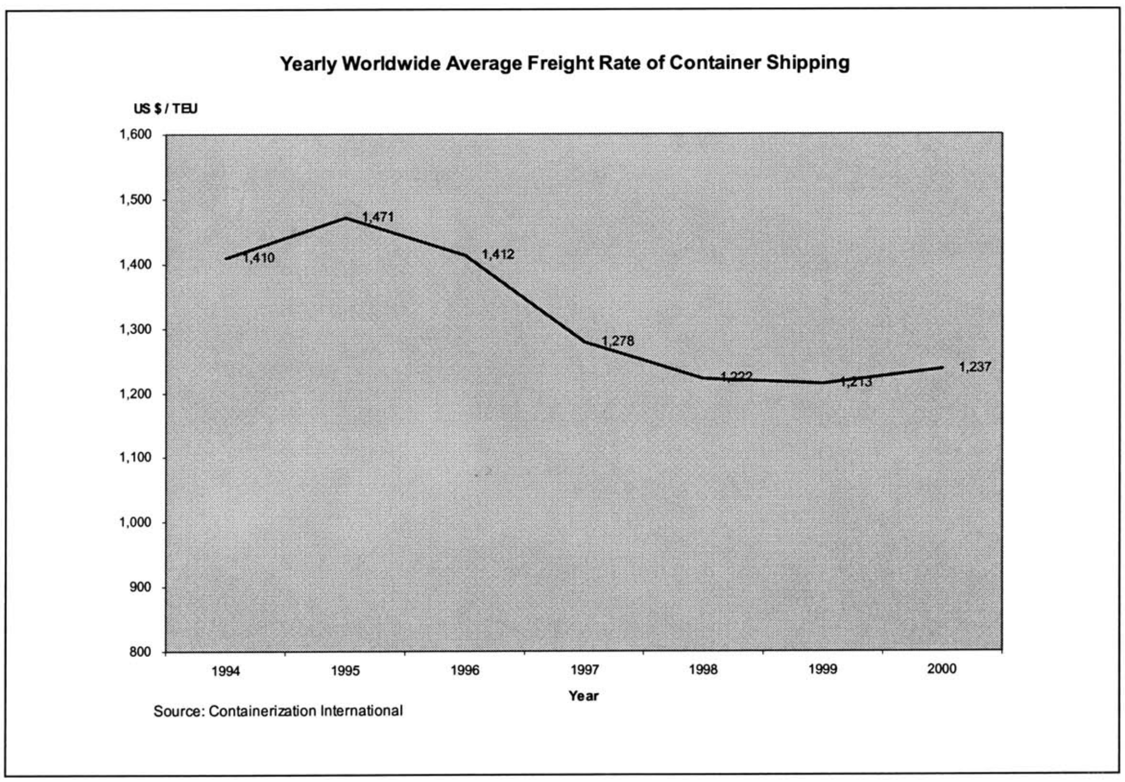


Figure 2-9 Worldwide Average Freight Rates in Nominal Terms (1994 - 2000)

2.5.2.2 Upsizing of the Containerships

The second supply-side driver of container shipping industry is the upsizing trend of the containerships. The containership fleet is becoming oriented towards even larger vessels. Not only are the largest ships in the fleet bigger year by year, but also there is a noticeable upsizing occurring throughout the fleet. Particularly, the upsizing trend has accelerated since the mid 1990s as post-Panamax containerships started to be delivered in a large numbers. The average size of containership delivered in 2000 was 2,894 TEUs, and the average size of containership on the orderbook for delivery in 2003 is 3,772 TEUs.[3] Additionally, Table 2-3 shows that the share of orderbook of 6,000+ TEU containerships has increased from almost nothing in 1995 (3.2% of total orderbook) to a quarter of total orderbook in 2000 (25.4% of total orderbook).

Table 2-3 Development of Orderbook of 6000+ TEU Containerships

At end-	6000+ TEU Containerships Orderbook			Percentage
	# of ships	1,000 TEUs	Total Order Book (1,000 TEUs)	
1995	4	24.0	754.8	3.2%
1996	17	110.6	991.8	11.2%
1997	14	109.8	898.9	12.2%
1998	12	91.9	691.8	13.3%
1999	24	172.1	902.3	19.1%
June 2000	50	322.6	1,271.7	25.4%

(Source: Ocean Shipping Consultants (2000), "North European Containerization")

The main reasons for introducing the large containerships are not only to accommodate the increasing demand for container shipping service, but also to utilize the economy of scale so as to reduce the unit total cost of operation. In other words, given the low profit margin due to the chronic overcapacity situation, carriers should reduce the unit cost of operation by spreading the capital and operating cost over a large number of container capacity. According to the research (Lim, 1998) on the cost savings of economy of scale

[3] Clarksons Research Studies, (2001), "Shipping Market Outlook – Spring, 2001" p. 41.

in the container shipping industry, a 6,000+ TEU containership could provide 21% cost savings of operation compared to the case of a Panamax containership.[4] A recent study on the benefit of economy of scale from a very large containership – a 18,000 TEU containerships – also confirmed the potential cost savings of economy of scale (Wijnolst, *et al.*, 2000). Given this cost savings of large containerships and low profitability environment, the upsizing trend of the containership will be a crucial competitive driver of the container shipping industry and the trend will force carriers to be more efficient cost managers.

2.5.2.3 Continuing Consolidation of Carriers

Besides the chronic overcapacity and upsizing of the containerships, the container shipping industry has also undergone consolidation among the carriers. The consolidation of carriers in the container shipping industry has evolved through three different stages: cooperation, alliances, and M&A (Merger and Acquisition).

Cooperation between carriers has long been a feature of the container shipping industry. Carriers have cooperated one another to achieve wider port coverage, higher service frequency, and lower costs through the use of larger containerships. For example, in its simplest form, if two carriers have one sailing a week, they can offer their shippers two sailings a week by simply buying slots off each other and thus avoid the need to purchase new vessels to introduce a second weekly sailing. Although cooperation can entail costs on an administrative level, the costs can be outweighed by the benefits which economy of scale provides. The cooperation varies in its levels of commitment. Ranked from lowest to highest commitment, there have been four types of cooperation: slot purchase, slot exchange, vessel-sharing agreement, and joint service. These four forms of cooperation tend to be trade specific.

[4] A containership that can pass through the Panama Canal. The Panamax containership is no wider than 32m and has generally the container carrying capacity of lower than 4,000 TEUs.

The second stage of consolidation of carriers is the alliances. The alliances were established to initiate cooperation among the members on a global basis and to extend cooperation to land-side functions as well. The first alliance, the Global Alliance, was formed in 1994 by APL, OOCL, MOL, and Nedlloyd, and other alliances were subsequently followed. After a couple of restructurings of the alliances, four alliances remained stable since 1997 (Table 2-4). The advantages of an alliance over cooperation are wider service coverage, more cost savings, and possible future service developments (ING Barings, 2000).

Table 2-4 Membership of Alliances

Alliances	Member Carriers
New World Alliance	APL/NOL MOL Hyundai
Grand Alliance	P&O Nedlloyd NYK Hapag Lloyd OOCL
United Alliance	Hanjin DSR-Senator UASC
K-Line/Yangming/Cosco	K-Line Yangming Cosco

(Source: ING Barings, 2000)

The formation of the alliances was a prelude to a series of mergers and acquisitions during the 1996 – 1999 period. The most significant examples of M&A involved on the main east-west trades and are detailed in Table 2-5. Other M&A's have been relatively small-scale and have focused on the north-south trades, where niche carriers did not have the strength to remain independent.

Table 2-5 Large Mergers and Acquisitions in the Container Shipping Industry (1996 - 1999)

Mergers		Acquisitions		
Companies Involved	Year	Company Acquired	Purchaser	Year
P&O Containerlines - Royal Nedlloyd → P&O Nedlloyd	1996	CMG	CMA	1996
		DSR-Senator Lines	Hanjin	1997
		APL	NOL	1997
		Sea-Land	Maersk	1999

(Source: ING Barings, 2000)

The M&A activities are basically cost-driven, and do underline the fact that even the close cooperation and alliances between carriers cannot completely squeeze out costs. The M&A can provide opportunity for cost savings in administration as well as the operational sphere. In fact, P&O Nedlloyd reported in the second quarter of 2000 that the cost saving program was on course to reach \$100 million by the end of 2000 and \$180 million by 2001 (ING Barings, 2000).

The result of this continuing consolidation of carriers is the increasing concentration of carriers in the CSI. In 1990, the top 20 carriers controlled approximately 40% of the global container slots. In 1995, their share grew to 50%; three years later it jumped to 77%. By 2000, the top 20 operators controlled 81% of the worldwide container slots (Figure 2-10). Moreover, the biggest carrier, Maersk-Sealand, is twice the size of its nearest competitor and controls 12.5% of all container slots worldwide and moves around 10% of world container traffic.

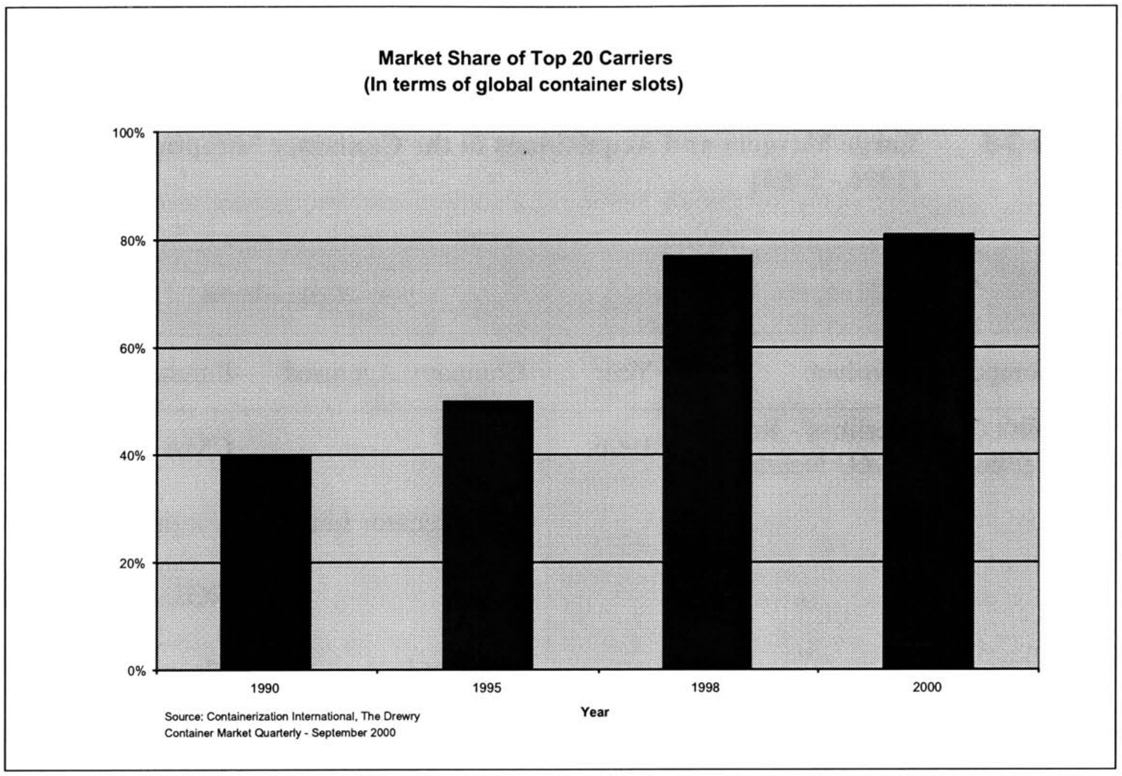


Figure 2-10 Concentration of Carriers in the Container Shipping Industry

Overall, supply-side drivers – chronic overcapacity, upsizing of the containerships, and continuing consolidation of carriers – imply that the container shipping industry is becoming so commoditized that efficient cost management is a primary success factor for carriers.

2.5.3 Environmental Drivers

In addition to the demand and supply sides, environmental drivers also substantially impact the dynamics of the container shipping industry. Among the environmental drivers are deregulation and technological evolution.

2.5.3.1 Deregulation

The container shipping industry has been regulated under the conference system as well as through other governmental means. In determining the freight rate, carriers have traditionally enjoyed the benefits of conference – a cartel that allows the carriers to set the freight rate collectively. Through the conferences, which have been regulated under US law since 1916, carriers could set common tariffs among members and have more bargaining power over shippers in the freight rate settings.

Although the conferences have always operated under legal restraints which aimed at preventing any abuse of monopoly power, there has been a general international acceptance that the benefits of a stable container shipping environment outweighed the drawbacks of allowing the operations of cartels. As a matter of fact, after a series of legal judgments against conferences, they were gradually replaced by "stabilization agreements" in the late 1980s and early 1990s. These agreements were looser confederations of carriers, which usually included leading non-conference carriers. The primary function of the stabilization agreement was the regulation of capacity rather than direct control of freight rate making. Over time, the stabilization agreements tended to absorb the conferences and have taken over the conferences' functions and responsibilities in some cases.

Despite the weakening role of conferences, regulators and shippers were not satisfied with the collective rate-setting practices of carriers, and tried to introduce more market-driven environment. After years of intensive negotiations among carriers, shippers, and regulators, the Ocean Shipping Reform Act (OSRA) of 1998 was enacted and has been effective since May 1, 1999. Key provisions of the OSRA include:

- OSRA allows shippers and carriers to enter into individual confidential service contracts

- Carriers can maintain antitrust immunity with the limited scope of permissible concerted activities

- Tariffs are no longer filed with the FMC (Federal Maritime Commission), but must be made publicly available.

A recent study on the impact of OSRA concluded that the deregulatory movements under OSRA have provided more market-driven environments for the container shipping industry (FMC, 2001). First of all, the number of service contracts has increased dramatically. The number of service contracts and amendments has increased by 200 percent since May 1999 and the volume of cargo moving under service contracts has also increased. In certain of the major trade routes, some shippers now are moving nearly 100 percent of their cargo under service contracts. Carriers generally report that 80 percent or more of their containers move under service contracts.

The second noticeable impact of OSRA is the de-emphasis of traditional conferences and a dramatic increase in efficiency-enhancing operational types of agreements such as vessel sharing and space charters. While there were 35 conference agreements on file with the FMC in1998, there were only 19 as of June 1, 2001. Operational agreements made up 58 percent of all effective agreements as of June 1, 2001. In addition, most shippers (98%) currently prefer negotiating one-on-one with individual carriers for confidential service contracts, instead of negotiating with rate-setting conferences or group of carriers (FMC, 2001).

In summary, the deregulatory impacts of OSRA will be an important driver of the container shipping industry. Particularly, OSRA will emphasize more of a market-driven rate-setting environment. In other words, OSRA may help carriers move away from the lowest price mentality because shippers would like to work with carriers who are able to provide more shipper-friendly services – e.g., logistics-related services. Carriers could have a real opportunity of differentiation. So successful carriers in the OSRA era should establish close contractual relationships with major clients across global trades and be an integral part of shippers' supply chain processes.

2.5.3.2 Technological Evolution

The container shipping industry has been affected by several technological evolutions historically. After the introduction of containerization in the 1950s and 1960s, the container shipping industry saw the development of intermodal transportation in the 1970s, the double-stack train system in the 1980s, and the introduction of EDI (Electronic Data Interchange) connections in the mid 1990s. Each technological evolution has left unique impacts on the container shipping industry,[5] and it is still an important competitive driver of the CSI.

A major focus of the historical technological evolutions was to reduce the costs of operation so that carriers could survive despite the ongoing commoditization processes in the container shipping industry.

New internet-based business (e-business) models, which have entered into the container shipping industry since 1999, now represent another technological evolution in this industry. Two e-business models – CTP (Collaborative Tool Provider) and e-PSP (e-Procurement Service Provider) – in the CSI will be more likely to succeed than other models, and have an impact on the CSI in the long run.[6] Unlike historical technological evolutions, new e-business evolutions in the CSI might help carriers not only lower costs of operations, but also improve logistics-related service offerings.

[5] Detailed impacts of technological evolutions in the container shipping industry will be discussed in the chapter 3.
[6] Detailed analysis on e-business models in the container shipping industry is discussed in the chapter 5.

2.6 Strategic Challenges of the Container Shipping Industry – Carriers' Perspective

Discussions on the competitive drivers of the container shipping industry provide a next question to carriers – how should carriers strategically respond to the competitive drivers? Carriers might have to accomplish two tasks to be successful: One is the "logistics service offerings (LSO)," and the other is the "efficient cost management (ECM)."

2.6.1 Logistics Service Offerings

The first task of carriers is to provide logistics service offerings (LSO) to shippers. The LSO is to provide not only container shipping service, but also logistics management services - e.g. door-to-door delivery, shipment tracking, just-in-time (JIT) inventory management, collaborative planning, and management of international trade documents etc. - to shippers.

The LSO is an urgent task of carriers in order to improve the current low profitability of transporting containers between ports. Because the traditional port-to-port container shipping service, or a "ocean-leg" container shipping service, has been substantially commoditized due to the chronic overcapacity problem, carriers cannot expect high profit margins from this business. Furthermore, shippers would not like to pay high premiums for the "ocean-leg" container shipping service since it costs only 30% of total door-to-door landed costs to shippers (Lim, 1998). Shippers consider the ocean-leg container shipping service less valuable than the overall logistics management service.

However, shippers' increasing demand for logistics service ensures that shippers are willing to pay high premiums for the logistics-related services and carriers can expect better profitability from them. For example, an industry survey (Reeve, 2001) showed that improving the global supply chain is one of CEO's top concerns. According to another survey (KPMG, 2000), shippers stressed that, in order to continue meeting their needs, carriers should provide logistics services such as, better shipment tracking, exception reporting, efficient invoicing/payment, online ordering, etc.

Besides the increasing demand for logistics service, the increasing importance of confidential service contracts between carriers and shippers under the Ocean Shipping Reform Act (OSRA) of 1998 could help carriers upgrade their logistics service capabilities. In other words, in order to receive an order from a shipper, carriers should prepare more customized, more differentiated service contracts, which must be tailored to the shipper's need – logistics service. As a result, under the OSRA system, the LSO will be an important strategic challenge for carriers.

Carriers have realized the importance of logistics services and started to offer them. Ongoing development of intermodal service (e.g. intermodal container shipping service, double-stack train system) and carriers' interest in acquiring logistics companies – e.g., recent purchases of logistics companies by Maersk Sealand and APL – clearly indicate this trend.

There might be two strategies for improving the logistics service offerings of carriers: vertical integration or virtual integration. Vertical integration means that carriers increase their logistics service offerings by internalizing the logistics service functions into one company organization. In other words, in the vertical integration strategy, carriers could hire an experienced logistics salesforce or acquire logistics companies to provide better logistics services to shippers. Meanwhile, a virtual integration approach is to invest in internet-based business technologies and develop a virtual collaboration platform to organize various logistics management functions between shippers and carriers.

2.6.2 Efficient Cost Management

The second strategic challenge of carriers, efficient cost management (ECM), helps carriers survive through severely commoditized environments in the CSI. Several competitive drivers explain that the CSI is so commoditized that efficient cost management is crucial for the carriers' survival. For example, the problems of empty containers and chronic overcapacity require carriers to be more cost-efficient; upsizing trend of the containerships proves the importance of economy of scale in the container shipping industry; and carriers have been gradually consolidated to reduce the costs of operation. Consequently, efficient cost management is another critical strategic challenge of carriers. Carriers have two choices for efficient cost management: reducing asset management costs and controlling transaction costs.

2.6.2.1 Control of Asset Management Costs

The asset management costs are related to managing the carriers' most expensive assets – containerships – including capital cost, fuel cost, ship supply cost, crew cost, and insurance cost. These asset management costs are fixed costs (except fuel cost), which carriers pay regardless of the number of containers transported. Therefore, the more carriers can reduce the asset management costs, the better profitability carriers can expect as long as the number of containers transported reaches minimum critical mass (Figure 2-11).

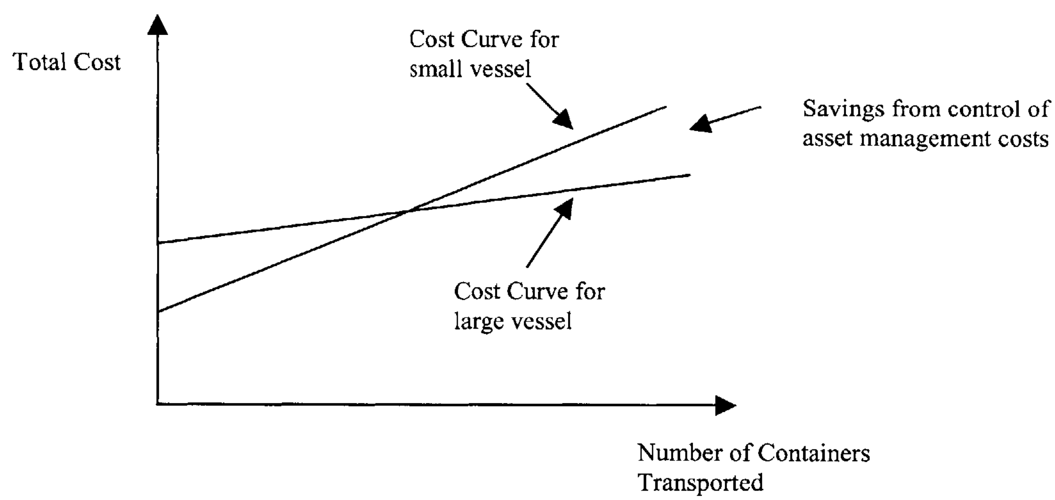


Figure 2-11 Benefits from Control of Asset Management Costs

Carriers have tried to reduce these asset management costs over time by using the economy of scale (e.g. ordering larger containerships), manning cheaper crews, or outsourcing ship management service. Recent carriers' efforts to implement e-procurement websites to reduce ship supply costs is also an example of reducing the asset management costs.

2.6.2.2 Control of Transaction Costs

Meanwhile, controlling the transaction costs is another crucial target of efficient cost management. The transaction costs are related to delivering the container shipping service, including market research cost, sales/marketing cost (e.g. customer acquisition cost), documentation cost, and customer support cost.

These transaction costs have generally increased over time: The recent deregulatory movement in the container shipping industry has provoked severe competition among the carriers to attract customers, thereby increasing the transaction costs of carriers. In addition, increasing information overload due to the increasing container traffic volume and increasing demand for logistics service by shippers has also increased the transaction costs in the CSI. Therefore, controlling the transaction costs efficiently is an important strategic challenge for carriers.

On the other hand, technological evolutions in the CSI have tried to reduce the transaction costs. For example, EDI connections reduced communication costs so that carriers could save overall transaction costs. Additionally, recent internet-based business activities could also provide potential savings of the transactions costs by utilizing low cost internet-based communication technology.

2.6.3 Trade-offs of Strategic Challenges of Carriers

The strategic challenges of carriers – logistics service offerings, control of asset management costs, and control of transaction costs – have internal trade-offs: carriers may not be able to improve one strategic challenge without sacrificing another.

First of all, improving the logistics service offerings could increase transaction costs. Because improving the logistics service offerings requires more sophisticated information management, carriers might have to hire more experienced salespersons and spend more money on market research; thereby increasing the transaction costs. Carriers should find a way of compromising this trade-off between the logistics service offerings and controlling the transaction costs.

The second trade-off occurs between the control of asset management costs and the logistics service offerings. Focusing too much on controlling the asset management costs could aggravate the level of commoditization of container shipping service so that carriers might not generate enough profitability to reinvest in improving the logistics service offerings. Therefore, controlling the asset management costs should be balanced with improving the logistics service offerings.

Chapter 3 Technological Evolution in the Container Shipping Industry

3.1 Introduction

This chapter describes the historical evolutions of the container shipping industry. First, the framework of technological evolutions for assessing the technological evolutions in the industry is summarized. Second, in order to apply the framework of technological evolutions to the CSI, historical developments of several industry variables in the CSI are reviewed. Third, the historical impacts of technological evolutions in the CSI are analyzed to provide insights into industry-wide impacts of technological evolutions. Finally, the discussion concludes that, compared with the framework of technological evolution, the current CSI is in the "mature" phase of technological evolutions, and hence it has several competitive characteristics.

3.2 Summary of the Framework of Technological Evolution

The framework of technological evolution has been developed by technology strategy theorists, population ecologists, and economists, such as Abernathy, Anderson, Klepper, Tushman, Utterback, and so forth, since the mid 1970s by investigating numerous technological innovation patterns in manufacturing industries. It has generally been accepted that such a framework is very useful to understanding the structural dynamics of industry within the context of technological evolution. Figure 3-1 shows that the framework is rooted on two important concepts – dominant design and technological discontinuity – and three phases (ferment, transitional, and mature phase).

The "technological discontinuity" – sometimes this is also called "technological disruption" – is a point in time when current technologies of an industry are replaced by a new revolutionary technology so that new industry dynamics are formed and competitive landscapes of industry are totally changed. After the technology discontinuity, there comes a period of time when various 'product innovations' are attempted and accomplished. Many newly founded companies are entering the market with different product designs and they are competing with one another and with industry incumbents based on the new product capabilities. The number of companies increases in a short period of time. This period is called the "ferment" phase of technology evolution. As the companies become more and more knowledgeable about the basic requirements of customers for the new product, the differences among the new products shrink. Finally, a "dominant design" emerges, where a set of basic technical functionalities of the product is intrinsically agreed upon among the industry players.

After the dominant design emerges, there usually comes a severe industry "transitional" phase, when the number of companies in the industry suddenly decreases substantially. The length of the transitional phase is generally shorter than that of the ferment phase. During the transitional phase, the number of companies sometimes decreases to less than 50 percent of the number of companies in the ferment phase.

The transitional phase is followed by the "mature" phase, when the number of companies stabilizes, accelerating the consolidation of companies. The innovation is more focused on the "process" of manufacturing rather than the product itself. A standard is often agreed upon among the players. The companies in this mature phase basically compete based on price rather than the quality of product. Economy of scale is sometimes very crucial for the competition. The product is substantially commoditized over time. In addition, complementary assets, such as brand, reputation, distribution channel, and so forth, which support the value of product, are more important for the competition than the technology itself embedded in the product. These complementary assets owned by the survived companies through the ferment and transitional phases provide high barriers to entry to the potential new entrants.

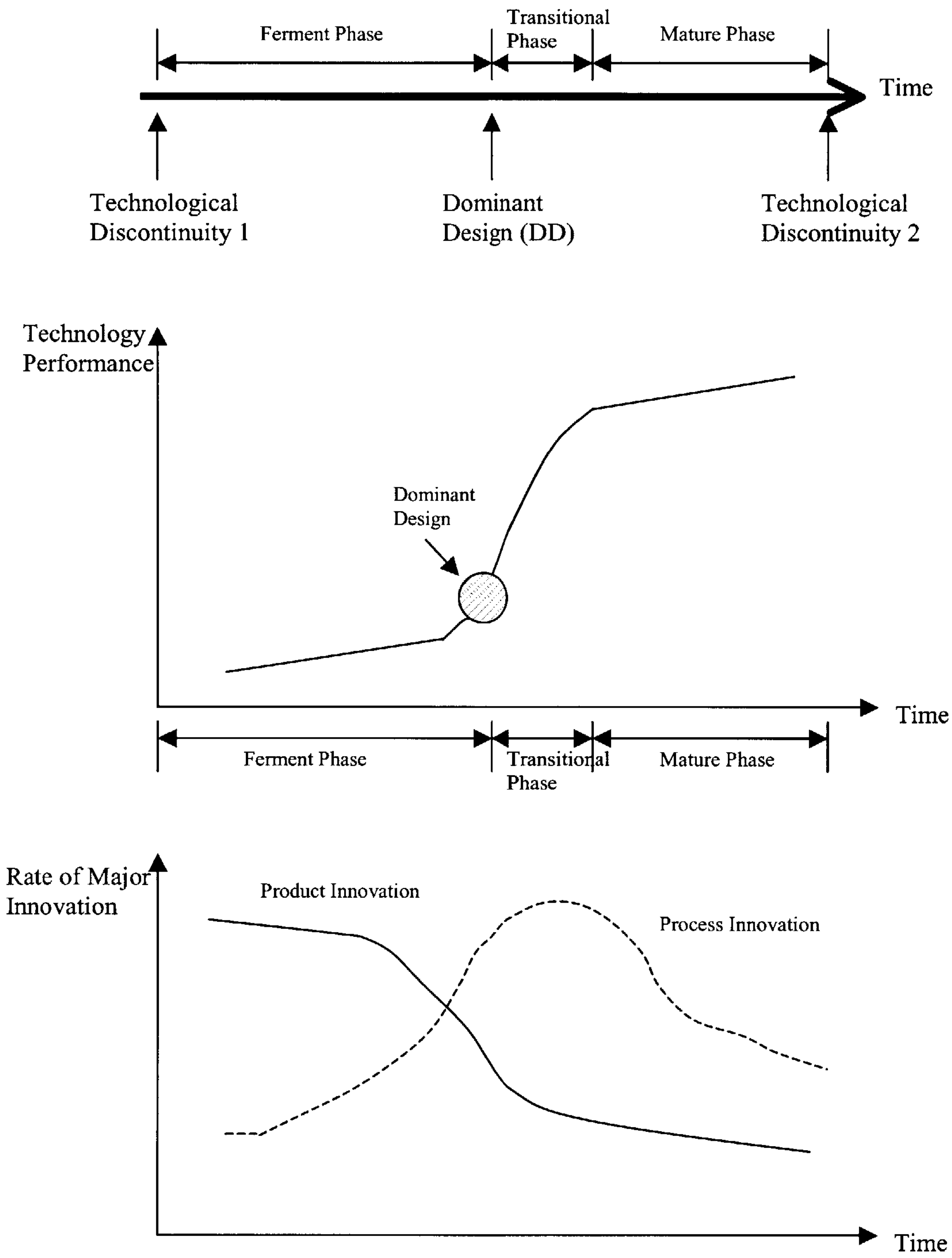


Figure 3-1 The Framework of Technological Evolution

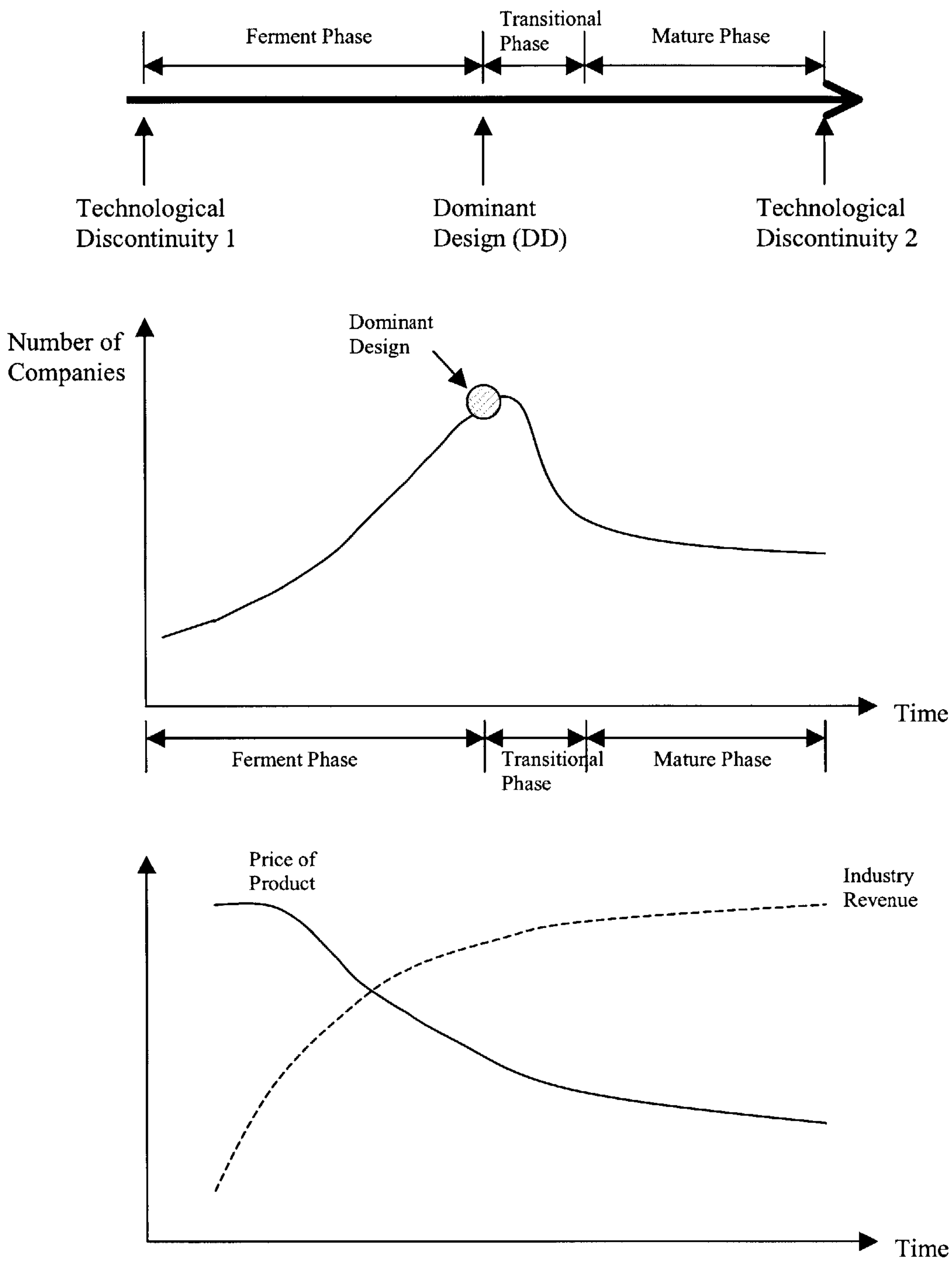


Figure 3-1 The Framework of Technological Evolution (Continued)

3.3 Historical Developments of Industry Variables in the Container Shipping Industry

The container shipping industry has been evolving continuously since its inception in 1956, when the first "containerized" cargo was transported between Newark, New Jersey and Houston, Texas. The framework of technological evolution discussed in the previous section emphasizes several important industry variables that can characterize the current technological evolution stage of the industry. Those variables include the number of companies in the industry, industry revenue, rate of innovation, price of product, etc. Modifying these variables to be applicable to the CSI, historical developments of several industry variables are examined in this section. Although much of the data has already been provided in chapter 2, they are described again in this section for the purpose of clearer explanation.

3.3.1 Number of Container Transported

Another measure of evaluating the technological evolution of the CSI is the number of containers transported, which is the demand side of industry dynamics. Figure 3-2 reveals that the number of containers transported has substantially increased over time. Despite the constant growth, the growth rate of the number of containers transported has decreased in recent years, confirming that the industry is approaching the mature stage.

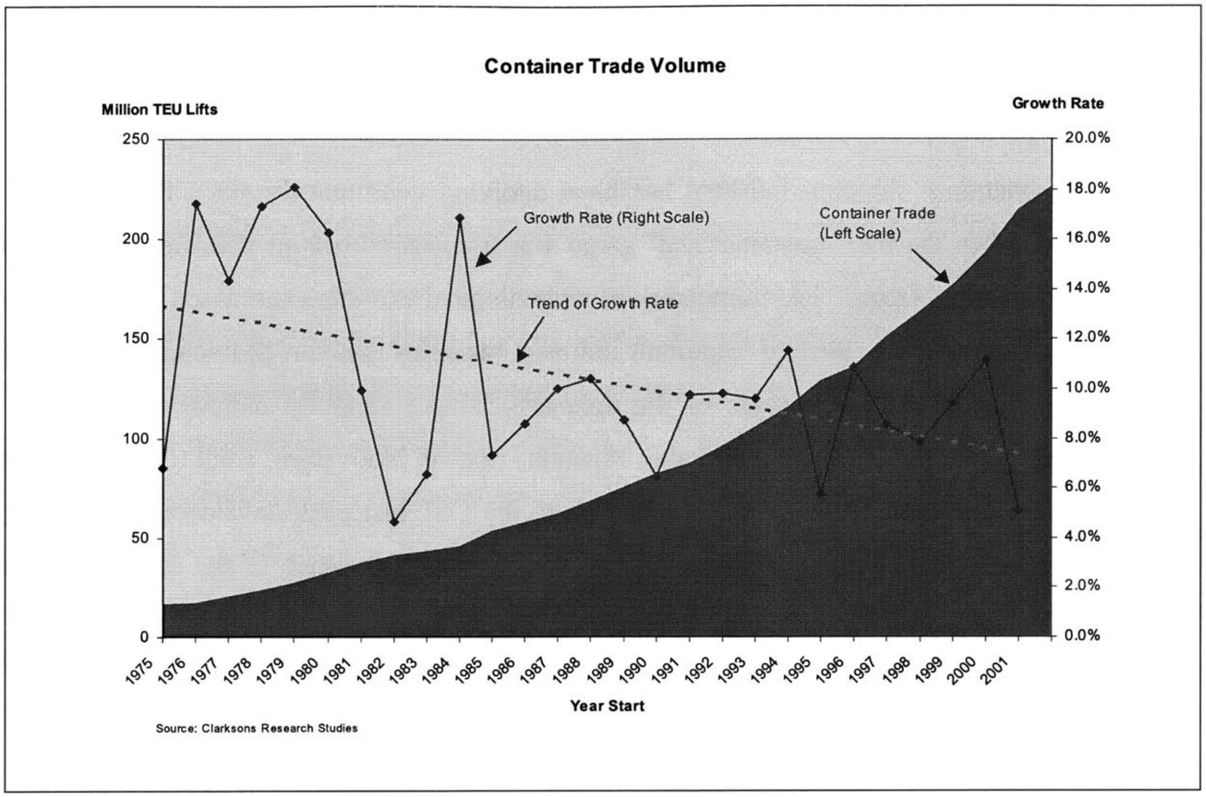


Figure 3-2 Number of Containers Transported over Time

3.3.2 Containerization Rate

As a proxy to the number of containers transported, containerization rate (CR), which is defined as the ratio of the containerized cargo to total general cargo that could potentially be containerized, is another measure of industrial evolution. Figure 3-3 shows that the CR has increased rapidly and now reaches around 50% of total general cargo in terms of weight. It should also be noticed that the growth rate of containerization rate has leveled off in recent years.

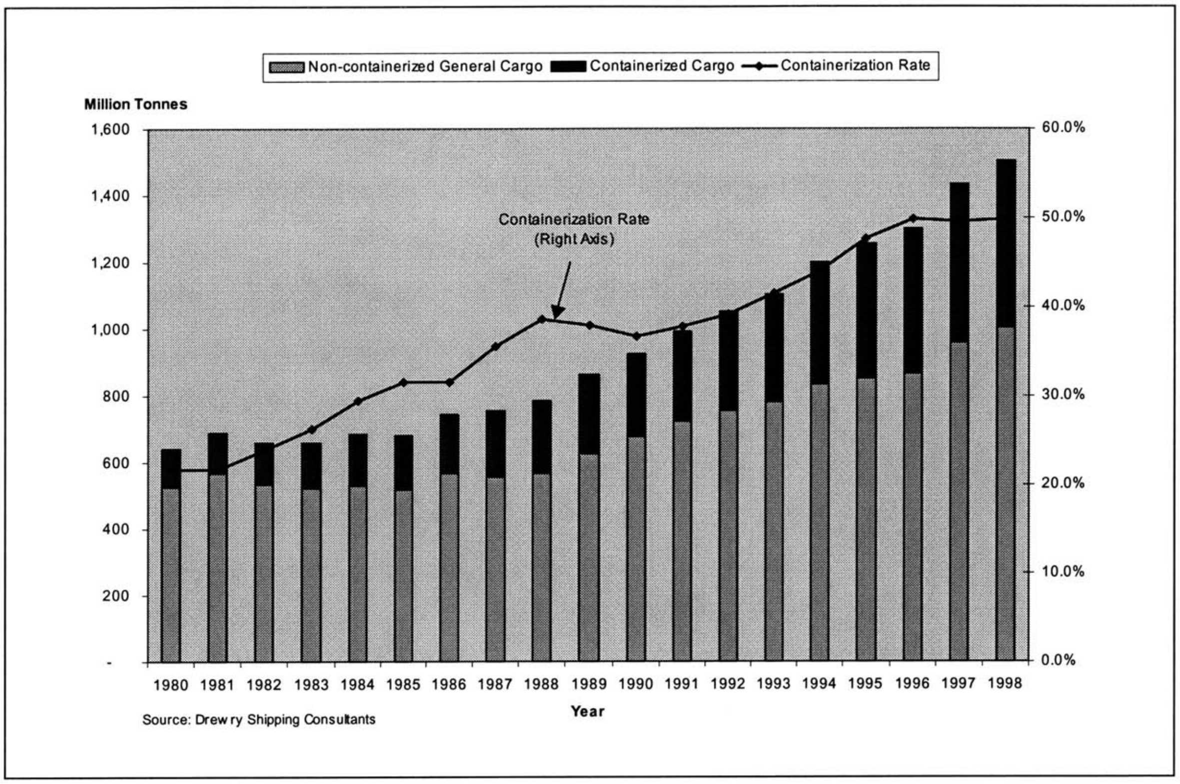


Figure 3-3 Historical Containerization Rate

3.3.3 Containership Fleet Capacity

Another indication of industry growth in the CSI is the containership fleet capacity (CFC), which is the supply side of industry dynamics. As shown in Figure 3-4, the CFC has dramatically increased over time. Unlike other industry variables, the CFC has increased relentlessly, i.e., showing a still high growth rate in the 1990s. This phenomenon illustrates that the CSI might have suffered from overcapacity sparked by the excessive capital investments, which resulted in constant decreases in freight rate as revealed in freight rate data.

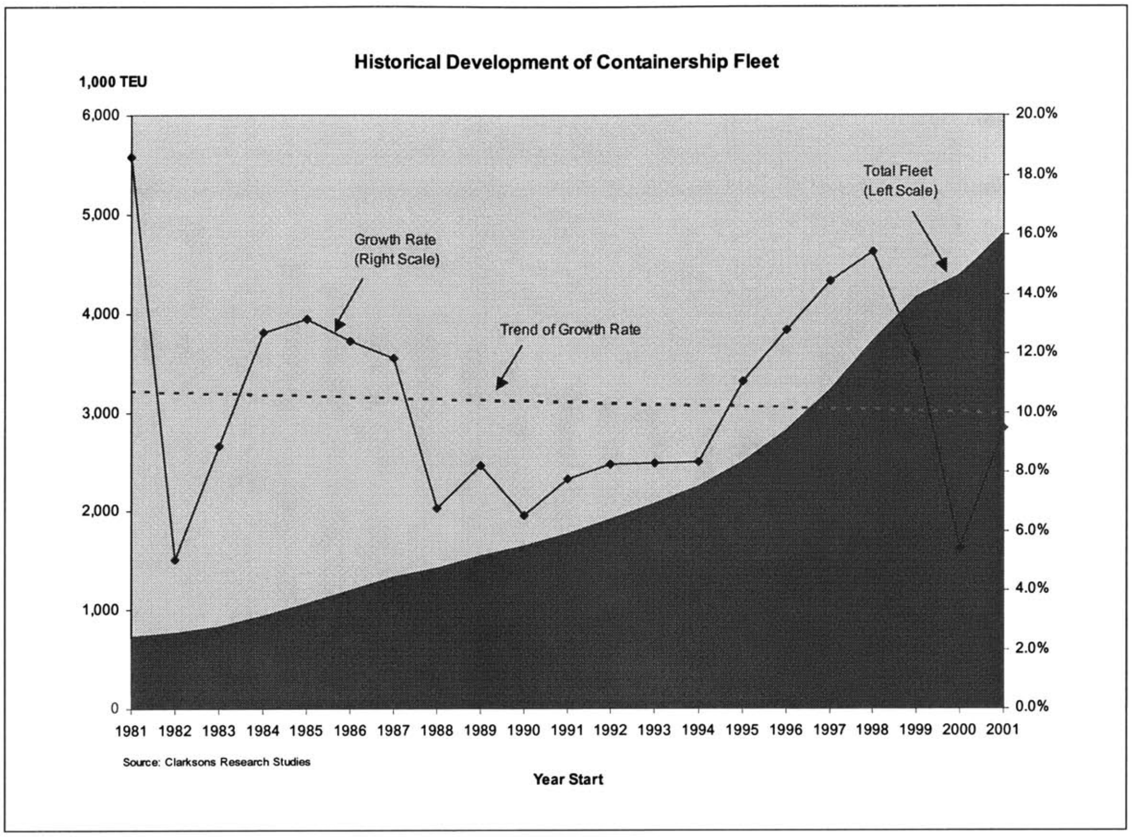


Figure 3-4 Containership Fleet Capacity over Time

3.3.4 Freight Rate

The historical data of the freight rate (Figure 3-5), which is a meeting point between supply and demand, clearly show that the freight rate has decreased substantially over time, both in nominal terms and real terms. The decrease trend in freight rate is much stronger in real dollar terms, adjusting for the inflationary effect.

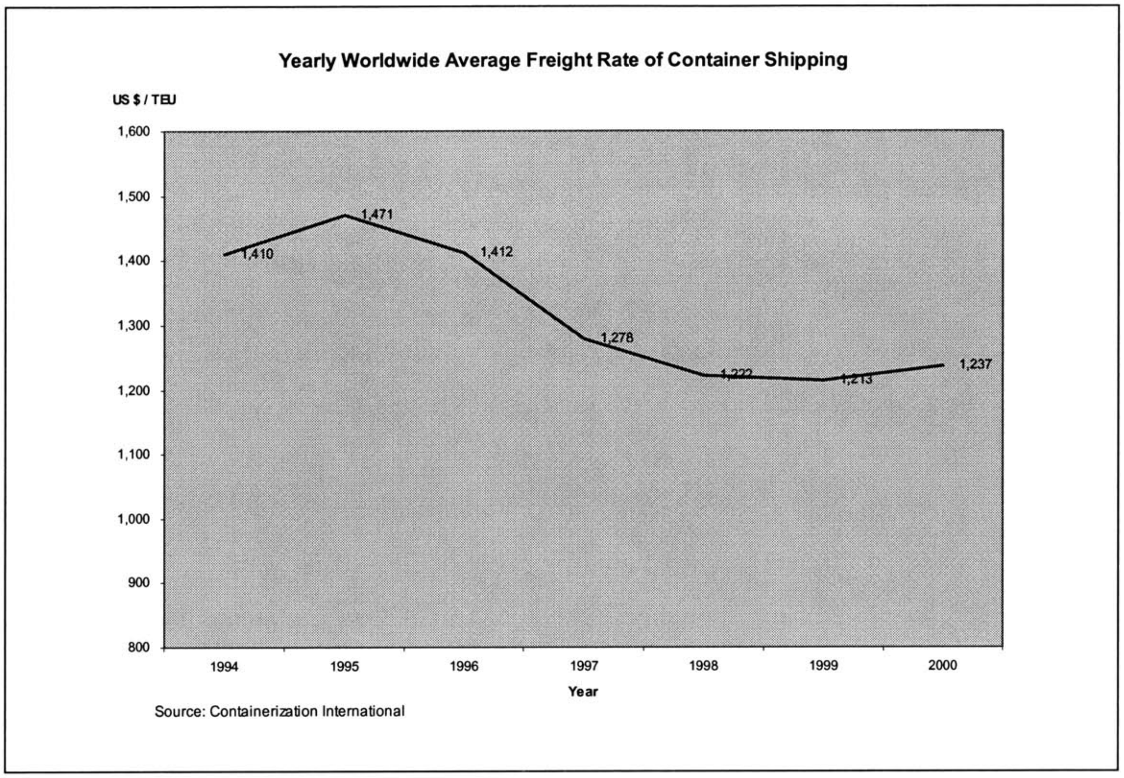


Figure 3-5 Worldwide Average Freight Rate in Nominal Terms

3.3.5 Number of Alliances

As discussed in the section of 2.5.2.3, the number of alliances and M&A deals have been increasing in the container shipping industry. Therefore, the consolidation of carriers has progressed over time so that the market share of large alliances and carriers has increased (see Table 2-4, Table 2-5, and Figure 2-10).

3.4 Historical Impacts of Technological Evolutions on the Container Shipping Industry

The container shipping industry has undergone ever-changing technological evolutions since its inception in the 1950s. Each technological evolution established new playing fields among industry players, and sometimes it created new rules of the game in the CSI. Unlike a fast-changing technology industry like the personal computer industry, the CSI has experienced relatively slow technological evolution over the 40-year period. Despite its relative slowness, however, the impacts of the technological evolution have been substantial not only on the CSI itself, but also on other logistics-related industries in general. This section reviews the historical impacts of the technological evolutions on the CSI based on the characteristics of the technology. Because of the limitation of information, the analysis focuses on the container shipping industry in the US. This analysis will serve as a starting point to analyze a new technological evolution, called internet-based business activities, which the CSI has recently been experiencing.

Historically, there have been four major technological evolutions in the CSI; containerization itself, early intermodalism, the double-stack train system, and EDI (Electronic Data Interchange) connections. Each evolution had a unique environment, which expedited the birth of the technological evolution, and also provided unique impacts on the CSI. Table 3-1 presents the summary of historical impacts of technological evolutions on the CSI, and detailed discussions follow.

Table 3-1 Summary of the Impacts of Technological Evolutions on the Container Shipping Industry

Technological Evolution	Time	Impacts on the Industry
Containerization	1956 ~1972	• Huge capital investment to build new containerships • The port authority's construction of new dedicated container terminals • Increase competition among ports • Increased tension around port labor • Emergence of ocean freight brokers

Technological Evolution	Time	Impacts on the Industry
Intermodalism	1972 ~ 1984	• More severe competition among ports from being a load center • Competition for premium service • Race for larger containerships • The increased importance of containership itinerary • Increased role of freight brokers • Higher quality service for shippers
Double Stack Train System	1984 ~ 1994	• Huge cost savings • Higher terminal operating costs • Increased information overload
EDI Connections	1994 ~ 1998	• Premium service to shippers • Need for collaboration • Increasing role of port authority for the EDI implementation

3.4.1 Containerization from 1956 to 1972

Containerization refers to a system which *adopts* the "container" holding cargo inside, *transports* the containers on ships, and further *dispatches* the container hauled on a tractor to the final destination. Containerization was first pioneered by Malcom McLean, who originally came from the trucking industry. He envisioned that ships could be very efficient tractors hauling many containers at a time. He converted a tanker from World War II into the first containership, *Ideal X*, and operated the first ocean container transportation system between Newark, New Jersey and Houston, Texas, in 1956. Table 3-2 shows major events of the technological evolutions in the early containerization period from 1956 to 1972.

Table 3-2 Introduction of Container Shipping Service from 1956 to 1972 [7]

Year	**Events**
1956	Ideal X sails from Newark to Houston – **Beginning of Container Revolution**
1958	California / Hawaii – by Matson Navigation Co. New York / Puerto Rico
1960	U.S. / Caribbean
1966	U.S. / Europe – **First Transatlantic Container Shipping Service**
1968	U.S. / Far East
1969	Europe / Australia Japan / Australia
1971	U.S. / Australia Europe / Far East

Two major factors were involved in the pioneering of containerization in the 1950s. First, government regulation, more specifically, the Jones Act, which precluded market-based competition in the US domestic ocean transportation routes, provided a safer environment to ocean shipping companies that freely experimented with new technologies without worrying about the risks of foreign competition. In other words, because foreign competitors were not allowed to transport ocean cargoes on the US domestic routes by regulation, McLean's Sea-Land, a US ocean shipping company, could deploy a containership on the route between Newark and Houston without the threat of foreign-flag competition. The second factor was the excess fleet capacity available in the 1950s, which was built during World War II. The US government in the 1950s sold its excess fleets to the US ocean shipping companies at prices substantially discounted from the

[7] Adapted from Franciose, M. M., (1994), Exhibit 4.

market price. This favorable financing option relieved the US ocean carriers of financial burden to construct new container ships in the early days.

Expedited by these factors, the newly developed container shipping system proved to be much more efficient than the traditional general cargo handling system, which required manual cargo lifting on and off ships. The container shipping system has provided (1) short ship turnaround time, (2) safer and more reliable cargo transportation, thereby lowering cargo theft enroute, and (3) significantly lowered transportation cost. Besides these direct benefits from the container shipping system, it changed the fundamentals of the ocean shipping industry. Those five changes are as follows:

- Huge capital investment to build new containerships

Before the containerization era, ocean shipping companies had never experienced pressure to upgrade their fleets in such a short period of time. However, the rapid development of the container shipping system pressured the ocean shipping companies to renew their fleets with expensive containerships. In order to minimize the risk of huge capital investment, the ocean shipping companies typically utilized government subsidies as much as possible. This heavy financial burden of expanding new containership capacity drove the container shipping industry to be capital-intensive by nature as opposed to being labor-intensive in the traditional break-bulk shipping era.

- The port authority's construction of new dedicated container terminals

As containerized trade volume increased, it required new cargo handling terminals that were equipped with container handling machines. Port authorities had either to invest in or to attract investments in new container terminals with container cranes, huge space for container depots, and efficient intermodal connections. In summary, port authorities had to transform themselves from labor-intensive to capital-intensive systems.

- Increased competition among ports

Because one of the direct benefits from containerization was short ship turnaround time to increase the productivity of an expensive containership, ocean container carriers should selectively dispatch their ships to fewer ports than before in order to maximize the productivity gain. Therefore, competition among ports to attract major container shipping carriers became more severe.

- Increased tensions around port labor

Increasing numbers of container cranes forced port workers to adapt to a new container handling system. Because the new container cargo handling system required only 20% of the traditional port workers[8], port unions regarded containerization as the enemy of their jobs. Therefore, this increased tension between port unions and container shipping companies caused several strikes and walkouts around the US ports in the 1960s. In 1968, the port union, ILA (International Longshoremen Association), representing the port workers on the Atlantic and Gulf Coasts, and container carriers agreed to the "50-Mile Rule," under which only union workers could load or unload containers within the range of 50 miles from the center of a port. Although it seemed to be a binding rule, the container carriers succeeded in bypassing the rule. In addition, the rule had very limited enforcement penalties for disobedience. After a series of legal battles in the 1970s, the rule was finally negotiated out of the master contract between the ILA and carriers from 1989 on.

- Emergence of ocean freight brokers

As rail and trucking industries saw the emergence of freight brokers, such as freight forwarders and consolidators, when they first introduced intermodal service like TOFC (Trailer on Flat Cars), containerization drew a new breed of ocean freight brokers into the container shipping industry. For example, the NVOCCs (Non-Vessel Operating Common

[8] *Ibid.*, Exhibit 22.

Carriers), who do not own containerships but wholesale the container slots from container carriers and resell them to shippers, started to provide marketing service for container carriers and logistics service for shippers. Although the NVOCCs were recently confronted with severe competition from container carriers, who have enhanced their management and marketing capabilities through increased computer support, the NVOCCs have played important roles in the early containerization era.

3.4.2 Intermodalism from 1972 to 1984

Starting in 1972, a landbridge intermodal service, which transports ocean containers from the West Coast to the East Coast by train and vice versa, was established and posed competition to the all-water shipping service through the Panama Canal. In 1972, Sea-Land, which had pioneered containerization under the guidance of Malcom McLean, first launched the mini-landbridge service between the West Coast and the East Coast. In 1979, American President Line (APL) began the first liner train service from Seattle to Chicago and New York.[9] The intermodal connection was provided via the COFC (Container on Flat Car) system in general, in which international ocean containers were transferred onto rail flat cars to be shipped to the final inland destinations on the other coast.

After the mini-landbridge system was launched, the deregulation of the rail and ocean transportation at the end of 1970s had driven the emergence of micro-bridge intermodal systems to ship ocean containers to the final inland destinations. Since the micro-bridge intermodal services did not compete with the all-water shipping service, they were complementary to the traditional all-water container shipping. The intermodal container traffic had increased quickly during the 1980s and 1990s. For example, although the number of the mini-landbridge trains operated in 1981 was lower than five a week, there were more than 240 dedicated weekly trains eastbound in 1995.[10]

[9] *Ibid.*, p.7
[10] Muller, G., (1995), p. 106.

Three major factors had affected the emergence of intermodal activities. First, the surge of Asian cargo bound for the US in the 1970s provided financial strength to container carriers so that they could experiment with the mini-landbridge intermodal service. Second, well-established rail networks, which had been already developed in the US, made additional intermodal operations on current rail systems less costly. Third, as a manufacturing system became more and more sophisticated in its inventory management, shippers asked for more reliable and faster transportation service from container shipping carriers, and hence they tried a new container shipping system via rail networks.

The intermodalism, exemplified by the mini-landbridge system, provided tremendous impacts on the container shipping industry. The impacts are as follows:

- More severe competition among ports for being a load center among ports

As ocean container shipping system became tightly connected to the inland transportation systems through intermodalism, competition among ports to be efficient intermodal connection centers became more intense. Because the intermodal container shipping, especially the mini-landbridge service was able to provide more reliable and faster service than the all-water container shipping service, more shippers would like to be served with the intermodal connections. For example, the Port of Los Angeles and the Port of Long Beach, which had excellent rail connections, started to become leading gateways from Asia to inland North America while the Port of New York and New Jersey lost many container shipping businesses because the majority of container cargo bound from Asia to the East Coast was transferred through the Port of Los Angeles and the Port of Long Beach. In addition, the fact that the volume of the Transpacific cargo was growing at a faster rate than the volume of the Transatlantic cargo exacerbated this phenomenon (Speirs, 1998).

- Competition for premium service

High oil prices in the early 1970s caused by the oil shock made ocean carriers abandon fast containerships with more than 30 knots and build larger containerships with slower speeds in the low-20 knots range. Despite the slow speed of containerships, shippers still requested faster and more reliable container shipping service. This shippers' request drove container carriers to develop intermodal service like the mini-landbridge service. Initially, the mini-landbridge service was the premium service of faster and reliable shipping. The intermodal container transportation between Asia and the Northeastern US was 6 days to 14 days faster than the all-water shipping system.[11] Only a few leading ocean carriers could offer this service, replacing the all-water shipping service. However, this premium mini-landbridge service was also commoditized over time so that most container carriers finally offered the mini-landbridge service.

- Race for larger containerships

Partly affected by high fuel costs, containerships became larger during the period of intermodal evolution. Besides the high fuel cost effect, the mini-landbridge system further expedited the race for larger containerships. Keeping transportation costs low through the mini-landbridge system required large volumes of container cargoes to minimize the unit transportation cost by spreading the cost throughout the longer intermodal routes. This strategy also applied to the double-stack train intermodal service as reviewed in the next section.

- The increased importance of containership itinerary

The larger containership size, driven by the intermodal evolution, emphasized the importance of itinerary choice for carriers as well as shippers because the careful itinerary choice could provide shorter container trip time. In other words, a US port, which a containership calls first, could offer shorter door-to-door container trip time to the final

[11] *Ibid.*, p.106

destination; the containers for shorter port-to-port trips should be unloaded first, unlike the rest of containers that would have to wait to be unloaded at a later port call. For example, if a containership from Asia calls on the Port of Seattle first and then on to the Port of LA, shippers served through the Port of Seattle could receive the containers faster than the shippers served through the Port of LA. For this reason, the containership itinerary became more important in the intermodal evolution.

- Increased role of freight brokers

As intermodal connections required many different kinds of transportation, freight brokers, which expedite efficient transportation service contracts between shippers and carriers, became more active than before. For example, because ocean shipping companies lacked experience in rail and trucking transportation, they tended to hire more freight brokers who helped find efficient ways of facilitating intermodal transportation.

- Higher quality service for shippers

Along with the deregulatory movement of the ICC (Interstate Commerce Commission) and the FMC (Federal Maritime Commission), a carrier was allowed to publish a single bill of lading covering door-to-door container movement from 1984 on, when the Shipping Act of 1984 was enacted. Before the intermodal transportation era, each carrier, who was responsible for port-to-port shipping, issued separate bills of lading. Accordingly, shippers had to deal with several different bills of lading to ship containers on a door-to-door basis. With the maturity of intermodal connections, however, shippers could enjoy the simplified and faster service with a single bill of lading issued by a carrier. In addition, intermodalism had removed stocking and restocking cargo inside the container throughout the entire shipment. In other words, the cargo remains in the same container for the entire door-to-door movement. This saved substantial costs associated with re-arranging the cargo inside the container.

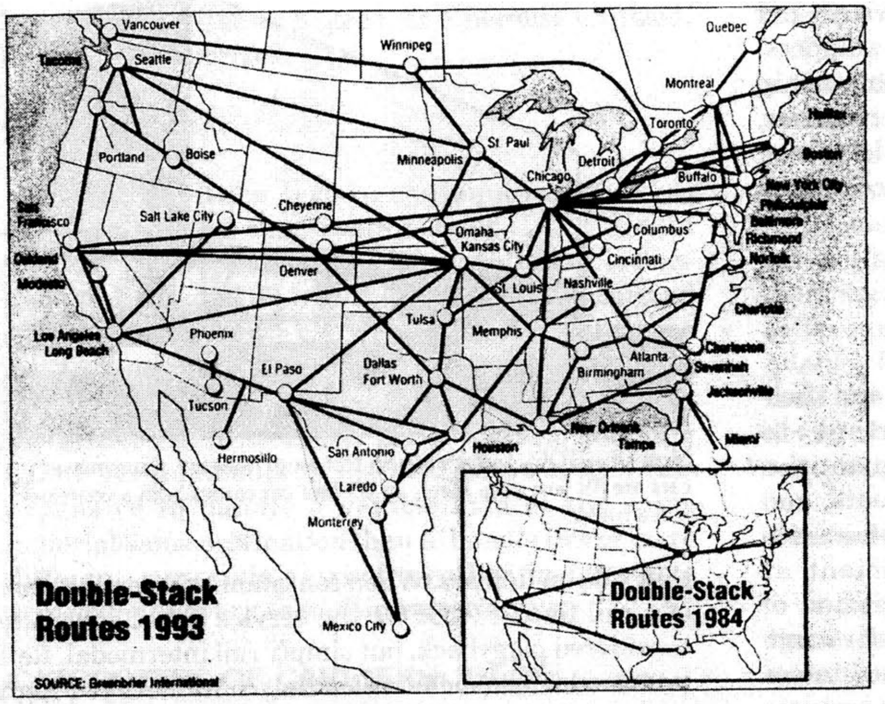
3.4.3 The Double-stack Train System from 1984 to 1994

As intermodal transportation systems in the US matured, the demand for intermodal service increased dramatically. In addition to this growing demand, liberalizing international trade regulations further increased container traffic in and out of the US. In responding to this growing demand, the container shipping companies gradually increased containership size. For example, while the maximum containership capacity was 496 TEUs in 1962, it grew to 3,000 TEUs in 1972 and 4,000 TEUs in 1980[12]. This growing container traffic increased pressure on the intermodal transportation system. Accordingly, container carriers experimented with new technological innovations that could possibly reduce the cost of container transportation.

In 1984, American President Line (APL) first started double-stack train (DST) service between LA and Chicago. The DST service transported two rows of containers – one above the other — on specially designed rail flat cars, thereby increasing the number of containers transported per locomotive. The service turned out to be more efficient and cost effective than the traditional TOFC (Trailer on Flat Car) or COFC (Container on Flat Car) intermodal services, which had evolved in the 1970s. Although the DST service required additional investment in new flat cars, which could accommodate double-stack containers, and in improved tunnel clearance and bridge safety, its benefits could offset the costs involved.

In 1984, when the DST service was first launched, only APL offered the DST service once a week between Los Angeles and Chicago. By December 1985, eight operators were providing the DST services from both coasts, with 32 eastbound DSTs a week. As of June 1988, 76 DSTs operated each week between 20 city-pairs. By the end of 1993, there was a total of 241 eastbound departures each week.[13] Figure 3-6 shows how quickly the DST service developed over time.

[12] Franciose, M.M., (1994), p.12 – 13.
[13]. Muller, G., (1995), p.65



Double-stack routes in 1993 compared to 1984.

Figure 3-6 Historical Evolution of Double-stack Train Intermodal Service

(Source: Muller (1995), p. 46)

Major impacts from the DST intermodal service are as follows:

- Huge cost savings

Cost savings from the DST system were enormous. The cost savings mainly came from two sources: First, the DST system enabled a reduction in capital investment cost because it could reduce the number of flat cars by stacking twice as many containers as the traditional intermodal systems. Second, since the length of the train was reduced due to the double-stack trains, the total weight of trains to be hauled by a locomotive became lighter so that carriers could also reduce fuel cost. One industry study showed that carriers could save up to 41% of fuel costs.[14]

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[14] *Ibid.*, p. 67

- Higher terminal operating costs

Because the DST need to be served efficiently, the use of DSTs increased the container handling operations in the intermodal terminal. The intermodal terminal operation had to be efficient enough to load and unload numerous containers in and out of double-stack trains. In other words, more investments in container handling equipment and labor were critical to successful double-stack train intermodal operations.

- Increased information overload

As containerships became larger and the number of intermodal containers increased, the amount of information associated with container handling increased substantially.

One interesting point of the DST innovation was that the CSI started to transform itself from "product" innovation to "process" innovation. In other words, in the context of the technological evolution, the dominant design of the container shipping service, which is to provide door-to-door intermodal service, was generally agreed upon. In addition, the CSI started to consider "price" of service as a main differentiator; i.e., the CSI was substantially "commoditized."

3.4.4 EDI Connections from 1994 to 1998

There have been several pioneering attempts to couple freight transportation with information processing. Table 3-3 shows the important historical attempts to introduce efficient information management into the CSI.

Table 3-3 Historical Attempts to Apply Information Technology into Container Shipping Industry [15]

Year	Events
1968	Foundation of Transportation Data Coordinating Committee (TDCC)
1983	Publication of ANSI X12 for EDI standards
1988	Adoption of EDIFACT as the official international EDI standards

An attempt to apply information technology to the CSI dated back to the late 1960s. In 1968, the CSI had founded the TDCC (Transportation Data Coordinating Committee), which was to develop standards to distribute transportation related documents efficiently among trading partners. The TDCC published several transaction standards in the 1970s. At the same time, the EDI technology began to evolve and be tested in several industries. The CSI had also tried to launch the EDI connections but it was not successful because of the lack of standards. In response to this problem, the first official EDI standards, ANSI X12, was published by the US ANSI (American National Standard Institute) in 1983, and subsequently in 1988, the International Standards Organization (ISO) adopted international standards for EDI, called EDIFACT (EDI for Administration, Commerce, and Transport). Thanks to these standards, EDI became popular in many industries in the early 1990s.

Noticing that the EDI was a useful tool for transportation-related information management and that the need for efficient information management in the CSI was increasing, the CSI started to adopt a new technological innovation, EDI connections, in the 1990s. The EDI directly connected trading partners through private data communication networks and allowed them to automatically interchange pre-formatted trade, transportation, or

[15] Adapted from Muller, G., (1999), p. 198.

transaction documents. Compared to traditional transaction communication technologies such as phone, telex, or fax, the EDI technology provided more secure, more reliable, and much safer trading environments to the users.

Major impacts from the evolution of EDI on the CSI are as follows:

- Premium service to shippers

The EDI service reduced transaction document errors, lowering the risk of sending cargo to a wrong destination. It also saved a lot of administrative work associated with transporting containers for shippers as well as for carriers. In addition, it provided more secure and faster trading environments.

- Need for collaboration

One of major obstacles to implementing the EDI was to develop standards that all users of EDI networks should follow. Without these standards, it was impossible to interchange information automatically. Therefore, the technological evolution of EDI gave the container shipping industry a new lesson that collaboration was important to the success of the CSI.

- Increasing role of port authority for the EDI implementation

Port authorities were very active in adopting the EDI system to attract container carriers. The port by nature is a meeting point where most players in the CSI, e.g., carriers, shippers, freight brokers, customs, etc., convene. Therefore, ports were able to be a key place to implement EDI networks. That is why many port authorities had tried to implement efficient local EDI networks to support container traffic through their container terminals.

3.5 Summary of Technological Evolutions in the Container Shipping Industry

The analysis of technological evolutions in the container shipping industry explains how the CSI has evolved and adjusted itself to the new technological innovations. The CSI has adopted four major technological innovations: containerization, intermodalism, the double-stack train (DST) system, and EDI connections. Each technological innovation has provided unique impacts on the CSI. Summing up the above analyses, several noticeable observations on the technological impacts on the CSI can be drawn as follows:

- Each technological innovation provided premium benefits to carriers as well as shippers, but the innovation itself became quickly commoditized. In other words, the innovators in the CSI have failed to protect exclusive rights for innovations so that late followers took advantage of the innovations without paying substantial premiums to the innovators. For example, the containerships and the container handling system, which were cutting-edge technological breakthroughs in the 1950s and 1960s, were quickly copied by the players in the traditional ocean shipping industry. Similarly, despite a series of technological innovations, the CSI became further commoditized over time.

- Each technological innovation in the CSI has attracted new breeds of industry players so that the boundary of the CSI has expanded over time. For example, containerization introduced new players in the form of container manufacturers, container leasing companies, ocean freight brokers, and container carriers; the intermodalism and DST system invited rail companies as new critical players of the CSI; and the EDI connections introduced IT companies as technology service providers.

- The regulating framework has been important in determining the speed of technological evolutions in the CSI, and the importance will be further emphasized for the adoption of internet-based business activities. For instance, the Shipping

Act of 1984, which allowed a single bill of lading for intermodal container movements, expedited the adoption of the intermodal container transportation system in the US. Additionally, it was not until the UN adopted the EDIFACT standards as the international format of EDI that the EDI connections became popular in the CSI.

Combining the above observations and the framework of technological evolution, it is concluded that the CSI has generally followed the patterns of technological evolution as explained in section 3.2. Supporting evidence for this conclusion is as follows:

- The "technological discontinuity" occurred in the ocean shipping industry when the first container shipping service started in 1956; i.e., "containerization" can be equivalent to the "technological discontinuity" of the framework of technological evolution.

- After the containerization was first launched, a series of "product innovations" were attempted through intermodalism and DST innovations. In other words, intermodalism and the DST system have focused on the "contents" of the container shipping industry to achieve efficient door-to-door container shipping service.

- In the wake of the DST innovation, the "dominant design" of the container shipping industry emerged, where a set of basic functionalities of the container shipping service was generally agreed upon among the CSI players. The dominant design of container shipping service include: the usage of standardized containers; shore-based container cranes to load and unload containers; door-to-door container shipping service using the intermodal connections via ports; the hub-and-spoke container transportation system, and so forth.

- After the DST innovation, the EDI connections began to provide a "process innovation," in which the framework of technological evolution expects to emerge after the acceptance of the dominant design. In other words, the EDI connections focused on improving the information processing of container shipping without changing the basic configurations of container shipping service. Moreover, current internet-based business activities in the CSI try to improve the process, not the product, of the container shipping service[16].

In conclusion, the analysis above argues that the CSI is now in the "mature" phase in the context of technological evolution. For this reason, we can draw several competitive characteristics of the CSI as follows.

- Barriers to entry into the CSI are relatively high because the CSI is capital-intensive, requiring huge capital investments to participate For the same reason, barriers to exit from the CSI are also relatively high.

- The management of complementary assets, such as brand, reputation, and distribution channel, is critical.

- The container shipping service has become so substantially commoditized that profitability of container shipping service is slim and efficient cost management is crucial for competition; hence, the competitive tactics to utilize economy of scale, for instance the usage of larger containerships, bigger containers, and more powerful container cranes, are widely used.

3.6 Conclusions

This chapter delineates the technological evolutions in the container shipping industry. Applying the framework of technological evolution reveals that the container shipping industry is in the mature phase of technological evolution, where the technological innovations are more focused on the process rather than the product. Furthermore, being

[16] The nature of internet-based business activities in the CSI will be further examined in the Chapter 5.

in the mature phase, the container shipping industry is substantially commoditized, thereby controlling the cost efficiently is important for the success.

In the next chapter, the evolution of EDI, which is the most recent technological evolution and is similar to the internet technology, is closely analyzed to improve the understanding of the impacts of new technology on the container shipping industry.

Chapter 4 The Evolution of EDI in the Container Shipping Industry

4.1 Introduction

Among the series of technological evolutions in the container shipping industry is the adoption of EDI (Electronic Data Interchange). The EDI, a computer-to-computer data exchange without human involvement, has provided various impacts on the container shipping industry in the 1990s. It is worth reviewing the detailed evolution of EDI adoption in the CSI because it has not only provided various impacts on day-to-day business practices in the CSI, but also it turned out to be the first step of a new technological evolution of the internet-based business in the CSI.

This chapter presents the detailed evolutionary dynamics of EDI adoption in the CSI, particularly focused on the activities from the late 1980s to the 1990s. Although the EDI adoption in the transportation industry in general dated backed to the late 1960s, it was not until the mid 1990s that the EDI adoption became important in day-to-day business practices in the container shipping industry.

This chapter is organized as follows: First, general information of the EDI technology, including the definition of EDI, technical structure of the EDI system, standards of EDI, and benefits of the EDI technology, is briefly reviewed. Next, evolutions of EDI adoption in the CSI are analyzed. Based on the case studies on several EDI projects implemented in the CSI, evolutionary dynamics, driving factors, and impacts of EDI adoption in the CSI are discussed. Then, interactions and comparisons of EDI and the internet-based business (e-business) are evaluated. Finally, based on the analysis of EDI adoption in the CSI, insights into the potential e-business dynamics in the CSI are presented.

4.2 Understanding of EDI

The first step into the research on EDI is to understand the EDI itself. In order to do that, this section reviews the definition of EDI, technical structure of the EDI system, standards of EDI, and benefits of the EDI technology.

4.2.1 Definition of EDI

EDI, or Electronic Data Interchange, has been defined in various terms depending on the researchers of EDI.[17] Despite the slight variations of the definition of EDI, EDI can be defined as follows based on Pfeiffer's(1992) and Sokol's(1995) works on EDI:

> EDI (Electronic Data Interchange) is the *intercompany computer-to-computer* communication of *standard business transactions* in a *standard format* via *telecommunication links.*

A brief explanation of five important components of EDI is presented in Table 4-1.

Table 4-1 Five Components of EDI Definition

Components of EDI Definition	Description
Intercompany	Intercompany refers to the electronic transmission of data between companies; i.e., the electronic transmission of data within the companies is not regarded as EDI.
Computer-to-Computer	EDI is to provide link between senders' and receivers' computers for business transactions without human intervention.

[17] Pfeiffer(1992) p. 17 – 18 provides several definitions of EDI.

Components of EDI Definition	Description
Standard business transactions	EDI does not refer to the transmission of e-mail or other free-form messages. Rather, the data in EDI should be standardized business transactions, such as invoice, purchase order, bill of lading, etc., in a computer-readable form.
Standard format	In order for the incoming EDI data to be recognized by the receiving computers, the transmitted business transactions must be in a predefined format.
Telecommunication links	The EDI data should be exchanged between the inter-company computer systems through telecommunication mediums, such as proprietary direct networks, value-added network (VAN), or the internet.

4.2.2 Technical Structure of the EDI System

Figure 4-1 illustrates the technical structure of the EDI system and explains how the EDI system works in reality. Let's suppose that a buyer and a seller exchange a group of purchase orders through EDI.

The buying company generates the purchase order transactions in its purchasing application just as it did in the paper environment. However, instead of printing the traditional paper document, it passes virtually the same information through two separate programs – application link and EDI translator – in the EDI system, which generates the computer-readable EDI standard file. This standard data stream is then transmitted to the seller's computer via telecommunication links. In the seller's computer system, the data stream is passed through the seller's EDI system, which maps the EDI standard fields into the simple file needed by the receiving computer application, edits and verifies the incoming information, and then passes it to the receiving order entry application for processing. The order entry application processes it just as it would do any incoming purchase order. These all processes are done automatically without human intervention.

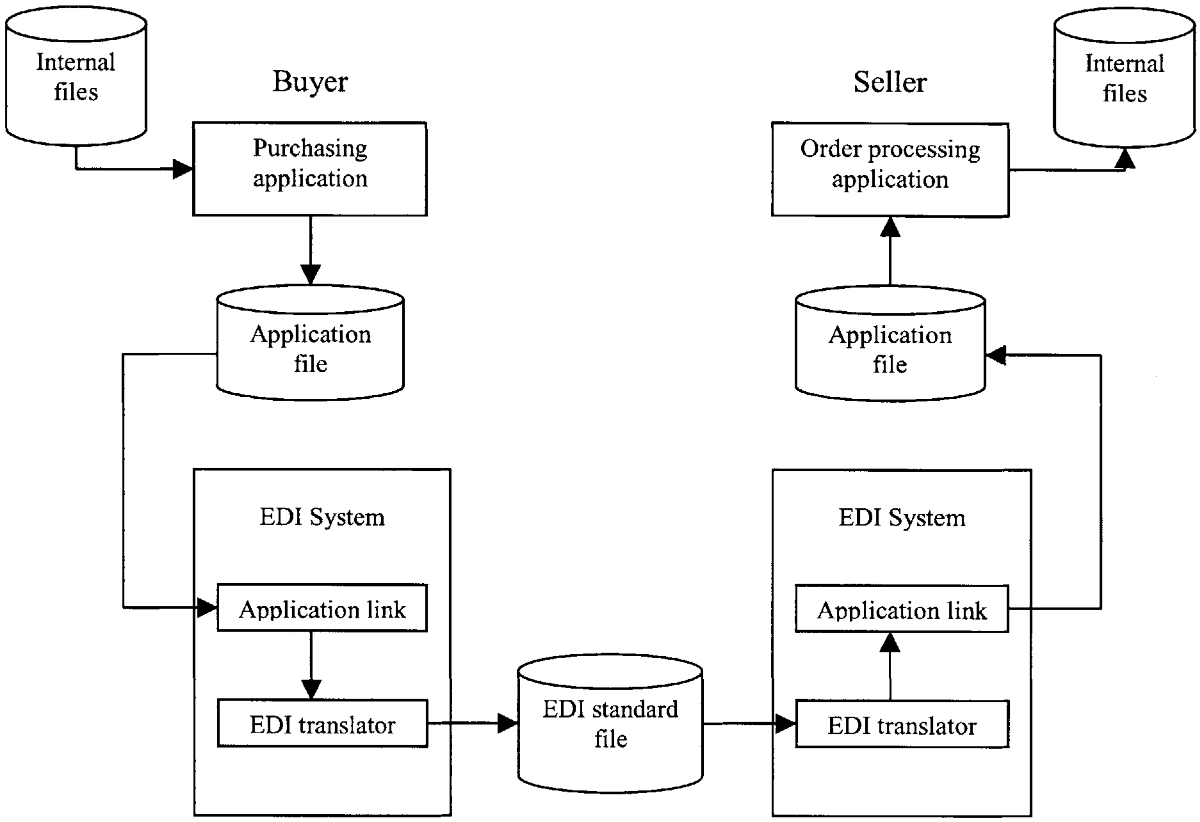


Figure 4-1 Technical Structure of EDI System
(Adapted from Sokol(1995) p.18 and p.20)

4.2.3 Evolution of the EDI Standards

EDI, by definition, exchanges standardized business transactions in a standard format; it is therefore a pre-requisite to have a standard that allows trading partners to communicate standardized business transactions between the computers without any human intervention. Indeed, the historical development of EDI has been dependent upon the evolution of the EDI standards. The evolution of the EDI standards has expanded from the national industry-specific standards to the international cross-industry standards. Table 4-2 presents the categories of the EDI standards that have been developed.

Table 4-2 Categories of the EDI Standards[18]

	National	International
Industry-specific	TDCC UCS WINS VDA	SWIFT ODETTE
Cross-industry	ANSI X12 TRADACOMS	EDIFACT

4.2.3.1 National Industry-specific EDI Standards

EDI started as a means to automate and systemize the documentation associated with the transportation industry. Besieged by mountains of paperwork associated with freight movements, major carriers, shippers, and financial institutions founded the Transportation Data Coordinating Committee (TDCC) in 1968 to standardize the way that transportation-related business transactions were handled. The first standards were published by the TDCC in 1975 for rail, motor, ocean, and air freight industry documents. Not until 1977 did the first EDI transmission take place when Conrail and Missouri Pacific Railroads began to exchange data for waybills.[19] The TDCC standards started to be adopted gradually by the transportation industry from the late 1970s; railroad companies were particularly active in implementing EDI with the TDCC standards.

Impressed by the early success of the EDI system in the transportation industry, several industries developed their own industry-specific EDI standards in the early 1980s based on the TDCC standards. Examples include the Uniform Communication Standards (UCS) in 1982 for the grocery industry and Warehouse Information Network Standards (WINS)

[18] Adapted from Pfeiffer(1992), p. 47.
[19] Muller(1999), p. 285.

for the warehouse industry. Both the grocery and warehouse industries started to implement the EDI systems based on their own EDI standards.

Besides the U.S., the German automotive industry developed its own EDI standards, or VDA, and implemented EDI system among the German automotive trading partners.

4.2.3.2 National Cross-industry EDI Standards

As the benefits of industry-specific EDI became apparent, the users of the EDI system looked for cross-industry EDI standards. In an effort to develop the cross-industry EDI standards, the American National Standards Institute (ANSI) chartered and accredited the EDI standard committee, X12, in 1979. The members of X12 committee encompassed a multitude of buyer and seller companies from many different industries, VAN service providers, and consultants in EDI, as well as the government. The first official cross-industry EDI standards, ANSI X12, was released in 1983.

The ANSI X12 has experienced an extensive follow-up until 1988 so that it became *de-facto* EDI standards in the US and Canada in the early 1990s. The TDCC for the transportation industry, the UCS for the grocery industry, and the WINS for the warehouse industry have all moved under the X12 organization's auspiccs. In addition, many industries, which started to adopt the EDI system from the mid 1980s, such as automotive, retail, chemical, electronics, petroleum, paper, and so forth, have adopted the ANSI X12 standards for their EDI systems.

Besides the U.S., the U.K. developed its own version of national cross-industry EDI standards, or TRADACOMS[20], which was used across a wide spectrum of industries in the U.K.

[20] Trade Data Communication Standards

4.2.3.3 International Industry-specific EDI Standards

Some industries that should deal with international business transactions have frequently developed their own international industry-specific EDI standards. Banks and other financial institutions were among the first industries to make use of EDI to accelerate data processing and the electronic funds transfer (EFT) for business transactions. The banking industry developed its own EDI standards, SWIFT[21], and has used it extensively for international electronic funds transfer. The other example is the ODETTE[22] standards employed internationally since 1984 within the European automotive industry.

4.2.3.4 International Cross-industry EDI Standards

Finally, the progression of the EDI standards comes to the international standard, supported by cross-industries in many countries. For this purpose, EDI for Administration, Commerce, and Transport (EDIFACT) was developed in 1987 based on the ANSI X12 and ODETTE standards. The EDIFACT was formally adopted by the United Nations to become the international EDI standards.

As of the year of 1995, over 80 business transactions were approved and being used under the EDIFACT standards. Although the EDIFACT standards have been developed for various areas of trade, the primary focus of EDIFACT has been on transportation.

The EDIFACT standards are now widely used in Europe and Asia for the international business transactions as well as for the national ones. Particularly, Asian countries including Korea, Japan, Singapore, Hong Kong, etc. only use the EDIFACT standards because they started to implement the EDI systems in the early 1990s. However, in the U.S., EDIFACT is not as popular as in Europe and Asia because many industries have already established the EDI systems based on the ANSI X12 standards. Many industries

[21] Society for Worldwide Interbank Financial Telecommunication
[22] Organization for Data Exchange by Teletransmission in Europe

in the U.S. use the EDIFACT standards for only international business transactions such as filing customs documents.

4.2.4 Potential Benefits of EDI

Many practitioners and researchers have attempted to identify the potential benefits that EDI could offer. The benefits can be grouped into two categories (Pfeiffer, 1992): direct benefits and indirect benefits. The direct benefits are mostly operational savings related to the internal efficiency of the organization. Examples of the direct benefits include reduced transaction costs, improved cash flow, reduced inventory levels, and higher information quality. Meanwhile, the indirect benefits are mostly tactical and competitive advantages – for example, increased operational efficiency, better customer service, improved trading partner relationships, and increased ability to compete. Table 4-3 presents the list of the two types of potential benefits.

Table 4-3 List of Benefits from EDI[23]

Benefits	Reasons
Direct Benefits	
• Reduced transaction costs	• Elimination of paperwork; labor savings
• Improved cash flow	• Faster processing and exchange of information
• Reduced inventory levels	• Shorter order cycles; reduced ordering costs
• Higher information quality	• Increased timeliness, accuracy, and accessibility of information
Indirect Benefits	

[23] Adapted from Iacovou, *et al.* (1995).

Benefits	Reasons
• Increased operational efficiency	• Improved internal operations due to time and cost reduction and better information management
• Better customer service	• Shorter lead times; more timely information about transaction status
• Improved trading partner relationships	• Enhanced trust through increased sharing of information; elimination of nuisance factors (e.g., errors in orders); increased ability to participate in JIT programs
• Increased ability to compete	• Increased ability to reach new markets; increased ability to provide better service at a lower cost

4.3 Evolution of EDI in the Container Shipping Industry

The container shipping industry has been a pioneer in adopting the EDI technology, particularly for the international transactions. Ever increasing container volume and increasing demand for an efficient management of transportation-related documents forced the CSI to actively implement the EDI systems.

This section explores the historical evolution of EDI in the container shipping industry. Starting with basic structures of the EDI system in the container shipping industry, several case studies of EDI projects in the container shipping industry, dynamics of EDI adoption in the CSI, driving factors of EDI adoption, and impacts of EDI on the CSI are closely reviewed.

4.3.1 Basic Structures of the EDI System in the Container Shipping Industry

Current EDI systems in the container shipping industry have basic structures that enable seamless exchange of business transactions through the EDI networks among the trading partners. There are two basic structures of the EDI system in the container shipping industry from the carriers' perspective: The first is the EDI system for the 'service delivery' value chain and the second is the EDI system for the 'asset management' value chain in the container shipping industry.

4.3.1.1 The EDI System for the 'Service Delivery' Value Chain

The 'service delivery' value chain in the container shipping industry is related to how ocean container carriers interact with shippers and improve the customer service. Figure 4-2 presents the general structures of the EDI system for the 'service delivery' value chain in the container shipping industry.

In order to serve the shippers' information request on container delivery, carriers should first develop the EDI networks with shippers. This is the 'front-end' connection of the EDI system for the 'service delivery' value chain. After receiving the information request from shippers, ocean carriers must communicate with other trading partners that enable the movement of containers. As such, carriers develop the EDI networks with inland carriers (i.e., railroad companies, trucking companies), terminal operators, other ocean carriers, banks, marine insurance companies, and the Customs service. This is the 'back-end' connection of the EDI system for the 'service delivery' value chain. This back-end connection allows the carriers to respond to the shippers' request without human intervention.

The EDI networks can be connected through the direct communication lines among the trading partners, or EDI-VANs, which provide a central clearing house of the EDI messages.

To illustrate the operation of the EDI system for the 'service delivery' value chain, an example of the EDI transactions for export is provided in the following[24].

[24] The example is summarized from Sokol (1995), p. 241.

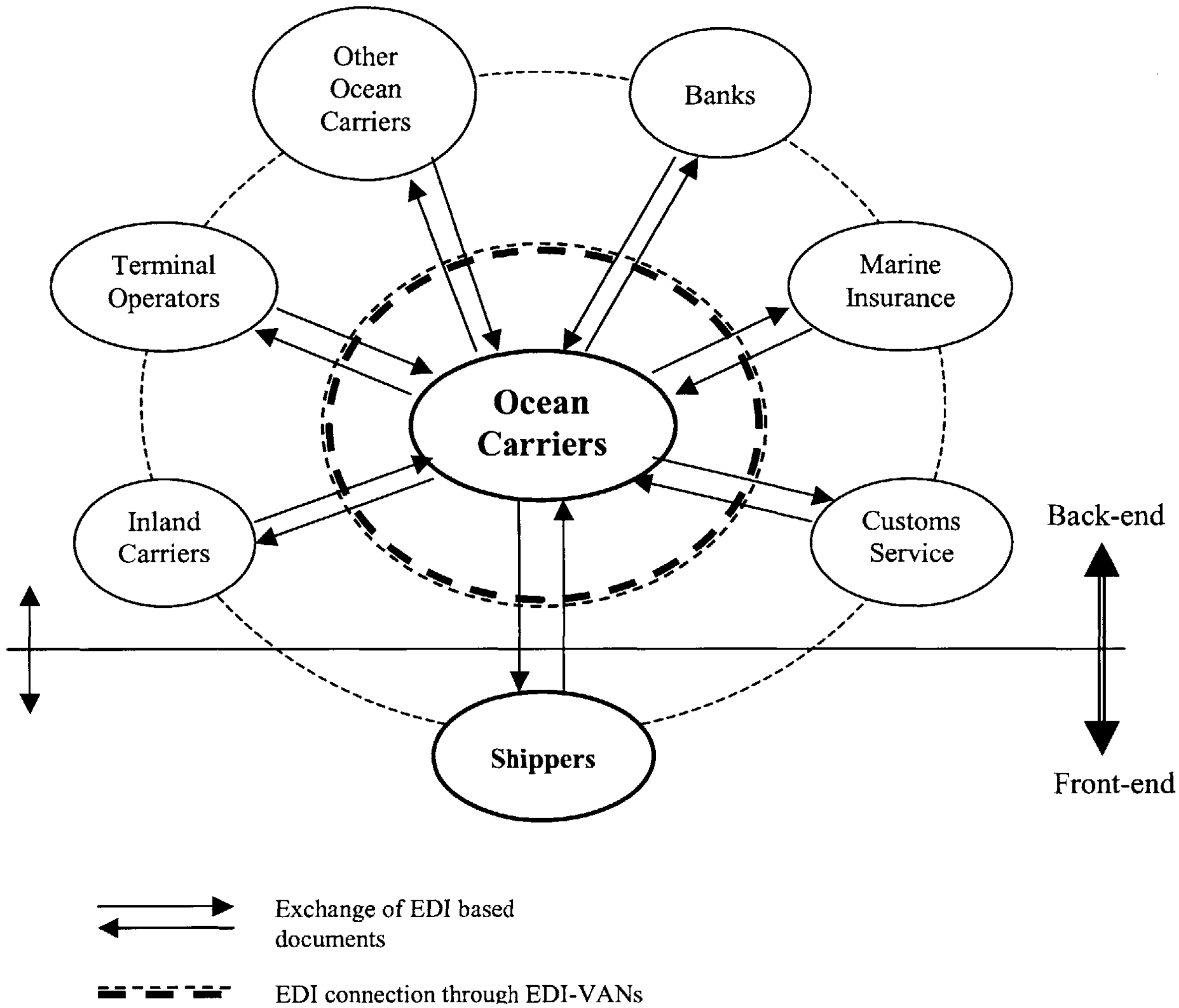


Figure 4-2 The EDI System for the 'Service Delivery' Value Chain of the Container Shipping Industry

First, the *booking request*, also known as the *reservation request*, is sent by the shipper to the ocean carrier, requesting either reservation of space, a shipping container, or equipment. It contains the information needed by the ocean carrier to understand the nature and routing of the shipment and to provide any special handling requirements.

Next, the *booking confirmation* responds to the booking request to confirm availability of space, containers, or equipment. This is a critical transaction set because just the sending of the request alone does not guarantee the booking. In the booking confirmation, the ocean carrier includes the booking number that it has issued. This number is used by the shipper as a shipment reference number until the bill of lading is issued with its identifying number.

After receiving the booking confirmation, the shipper returns the *shipment information*. It contains all the information needed to generate a bill of lading and to handle freighting and scheduling. The shipment information transaction set replaces the shipper's letter of instruction in the paper world.

The shipment information transaction set is followed by the *freight details and invoice.* This transaction set is sent by the ocean carrier to convey information regarding shipping charges. This transaction set may be thought of as the master document of both the import and export chain as it contains all information related to a shipment. While this transaction set contains the same information as the paper bill of lading, it cannot replace the bill of lading completely because of the legal issues on the electronic bill of lading. However, some carriers, for example APL, are developing the electronic bill of lading to replace the paper bill of lading.

Next is the *gate activity* or *terminal operations activity gate arrival* transaction set. This is sent by the shipper to inform the ocean carrier that containers have arrived at the port and are ready to be loaded into the vessel. At the same time, the ocean carrier issues the terminal operator a stow plan in which it identifies the exact location into which the containers are to be loaded in a vessel and tells any special handling requirements.

In addition, the *shipment inquiry* can be sent to the ocean carrier by the shipper to request information regarding the status of location of a shipment. The ocean carrier may then respond with the *status details reply* after exchanging the shipment status information with the terminal operators or the inland carrier. Sometimes the ocean carrier transmits the reply even though no inquiry has been made. In this case, the status details reply transaction set acts as a simple notification of status.

The EDI transactions for import follow a similar process, but they should interact with the Customs service. Following is the Example of the EDI transactions for import[25].

First, the *arrival notice* is transmitted by the ocean carrier to the importer or customs broker to inform them that a shipment is scheduled for arrival. It contains much of the same information as contained in the paper bill of lading.

Next, the ocean carrier issues a U.S. Customs Manifest. This shows the exact contents of the vessel. It is sent to the U.S. Customs office by the ocean carrier. Here both EDIFACT and proprietary U.S. Customs-developed formats are acceptable.

Just as in the export process, the *shipment inquiry* and the *status details reply* are included in the import process as well. The shipment inquiry is sent by the importer or customs broker to the ocean carrier, and the status details reply is returned.

Finally, the *gate activity* can be sent by the terminal operator to the ocean carrier to inform that the cargo has been removed from the ocean vessel and either passed to a local trucking company or to a railroad company for inland delivery.

4.3.1.2 The EDI System for the 'Asset Management' Value Chain

The 'asset management' value chain in the container shipping industry is related to how ocean container carriers manage their vessels efficiently. Figure 4-2 presents the general structures of the EDI system for the 'asset management' value chain in the container shipping industry.

[25] The example is summarized from Sokol (1995), p. 241 - 242.

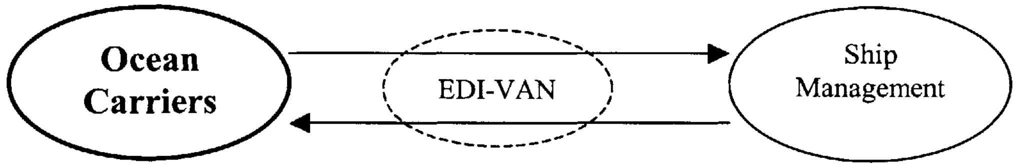


Figure 4-3 The EDI System for the 'Asset Management' Value Chain of the Container Shipping Industry

In this EDI system for the 'asset management' value chain, ocean carriers develop the EDI networks with ship management companies through either direct communication links or EDI-VANs, and exchange the EDI business transaction sets. An example of the business transaction sets in this EDI system is the *purchase order* sent by the ocean carrier to the ship management company to request the ship maintenance service. Responding to the purchase order transaction set, the ship management company sends the *invoice* after finishing the ship maintenance required by the ocean carrier.

Compared to the EDI system for the 'service delivery' value chain, the EDI system for the 'asset management' value chain is relatively less adopted in the container shipping industry.

4.3.2 Case Studies of EDI Projects in the Container Shipping Industry

There have been many EDI projects worldwide in the container shipping industry. Regardless of their success or failure, those projects provided the CSI with valuable experience in implementing the EDI systems. In order to understand the evolution of EDI in the CSI, this section reviews several EDI projects that were implemented in the CSI from the late 1980 to the mid 1990s. The examples were selected on a worldwide basis to provide a better picture of the level of EDI adoption in the CSI.

4.3.2.1 A Singapore Case: TradeNet[26]

TradeNet in Singapore is one of the most recently successful EDI cases in the container shipping industry. TradeNet was developed in the early 1990s under the active guidance of the Singapore government, particularly the Customs organization. It was the first nation-wide EDI system in the world: 95 – 98% of information related to trade and transport in Singapore is processed through TradeNet. Major characteristics of this project are outlined below:

TradeNet is a system that integrates documentation in the maritime community. In a community system, data are input once, are routed to partners, and are shared among them through a centralized clearing center; i.e., the users of TradeNet need to provide the details of cargo only 'once.' Figure 4-4 shows how TradeNet is organized as a community system.

- TradeNet, as a totally community-based system, has been initiated and designed by the maritime community to meet its own needs. It was developed based on the processes used by the nine major members representing the majority of users in the port community.

- TradeNet, together with PortNet at the Port of Singapore, reduces the documentation process for exporting a consignment from 35 to 16 steps and the processing period from 2 – 4 days to 15 – 30 minutes. Total cost savings from TradeNet are estimated at more than US $4 million per year.

- The Singapore government and the Customs organization have played a crucial role in developing TradeNet. In particular, cooperation and coordination have existed between the Trade Development Board, port authorities, and customs offices.

[26] Adapted from Lee, *et al.* (2000), p. 134 – 137.

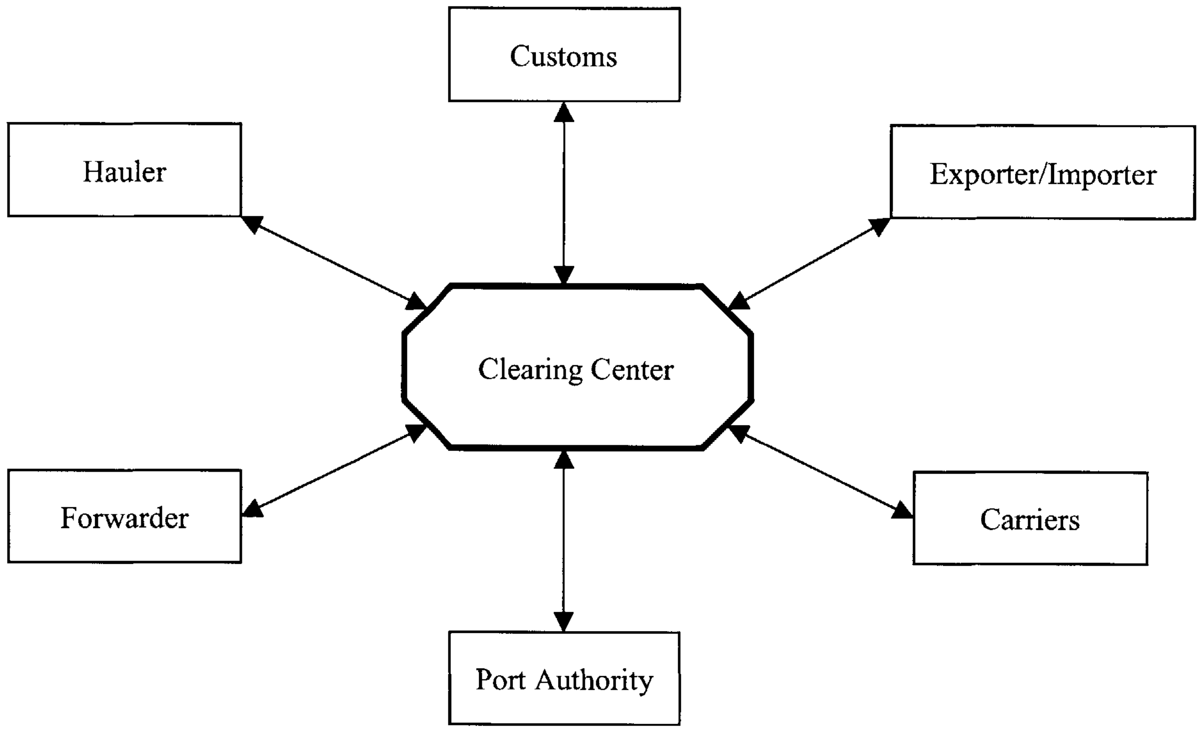


Figure 4-4 Network of TradeNet system

4.3.2.2 A Korean Case: KT-Net and KL-Net

The Korean trade and transportation industry has suffered from high documentation costs generated from export and import of containers. As many as 350 different paper documents are required, including the purchase order, waybill, bill of lading, letter of credit, customs declaration, and insurance certificate, etc. The total number of documents for international trade per day was estimated at 2 million documents, resulting in the cost of trade-related paperwork in Korea alone is said to be US $8 billion per year[27].

In order to reduce the trade-related documentation cost, two independent EDI systems were developed. The first EDI system is the Korea Trading Network (KT-Net). KT-Net

[27] Lee, *et al.* (2000), p. 138.

was established in 1990 by the Korea Foreign Trade Association under the guidance of the Ministry of Trade and Industry. The service of KT-Net covers licensing, insurance, customs clearance, duty drawback, shipment request, issuance of bill of lading, and so on. After a trial period in 1994, the main system started to provide full service from 1995. This system is more focused on providing EDI service to the shippers community. However, KT-Net did not cover the transportation-related documentation through ports, a parallel system was needed to close the gap in the EDI system for international trade.

The second EDI system is the Korea Logistics Network (KL-Net). KL-Net was co-founded in 1994 by container shipping companies, including three major ocean carriers (i.e., Hanjin, Cho Yang, and Hyundai Merchant Marine), the Busan Container Terminal Company (BCTOC), the Korea Container Terminal Authority, shippers, freight forwarders, and other professional maritime organizations. It aims to develop an EDI network for container cargo logistics, which would allow exporters and importers to exchange data with the maritime community. The main system became fully operational in 1995.

Despite the major effort to develop an EDI system in the Korean container shipping industry, the adoption of EDI in Korea has been lamentably slow so far. Three reasons might cause the slow adoption of EDI in Korea: First, the cost of using the EDI system has been too expensive for small and medium trading and transportation companies. Second, the sharing of information of cargo between KT-Net and KL-Net was not complete although both systems adopted the EDIFACT standards. Third, the Customs organization was not active in adopting the EDI system in its work procedure.

4.3.2.3 A Hong Kong Case: TradeLink

TradeLink is an EDI system for exchanging trading documents among the trading and transportation companies in Hong Kong. It was founded by the Hong Kong government and a consortium of banks, telecommunications, trading, and transportation companies in 1992. After a series of technical testings of its EDI system, TradeLink started to offer

EDI service for textile export licensing from the beginning of 1997. TradeLink has a seven-year franchise from the Hong Kong government to process all official trade documentation through its EDI network.

The adoption of EDI through TradeLink has been generally successful despite its starting later than other nations. For example, the average of EDI adoption of production notification document among the trading communities in Hong Kong as of January 2000 was estimated to reach 85% (Bangsberg, 2000).

The main reason for the success of TradeLink is an active involvement of the Hong Kong government with adoption of EDI. The Hong Kong government proposed the statutory trading documents to be processed through TradeLink and monitored the EDI adoption of each statutory trading documents.

4.3.2.4 The U.S. Case

The container shipping industry in the U.S. has been most advanced in implementing the EDI technology. Following the pioneering work of TDCC to develop the EDI standards for the transportation industry, most of large shippers, carriers, and port authorities have implemented the EDI networks since the mid 1980s to automate the exchange of transportation-related documents among the trading partners. Particularly, the U.S. has well established the intermodal EDI networks, which are hardly found in other regions.

Unlike the EDI systems in Asia and Europe, most EDI systems in the U.S. are based on the ANSI X12 standards, rather than the EDIFACT standards. This is because many U.S. industries including the transportation industry have already constructed the EDI systems with ANSI X12 well before EDIFACT became accepted as an international EDI standard. Although it is not difficult to transform the ANSI X12 based EDI documents into the EDIFACT based ones, and vice versa, this might hinder the U.S.-based EDI systems from being connected to the international EDI networks.

Below are examples of the EDI systems established in the container shipping industry in the U.S. These examples can provide the general pictures of the EDI adoption in the U.S.

EDI Systems in the U.S. Ports

Port authorities in the U.S. have been focal points in distributing container-specific information among the players in the container shipping industry. Many port authorities have already implemented the EDI systems to be used by the port users. A well known example is the Automated Cargo Expediting System (ACES) in the Port of New York and New Jersey. ACES, developed by the Port Authority of New York and New Jersey and GE Information Services, is a portwide computerized service, providing information on location and status of international maritime shipments. The information includes arrival notices from ocean carriers, manifests from ocean carriers to both U.S. Customs and the maritime terminal operator, delivery orders from customhouse brokers, cargo status replies from marine terminals, and electronic bookings from freight forwarders to ocean carriers.

Linked by GE's global network and electronic data interchange (EDI*EXPRESS) services, ACES allows users to streamline the information management process, speeding cargo transfers, reducing information delays and errors, improving customer service, and increasing office productivity. Figure 4-5 shows a brief structure of ACES.

Another example of the EDI system in the U.S. port is LINX used by the ports of Seattle and Tacoma. LINX provides the region's transportation community with an EDI information exchange system to optimize cargo movement, providing users with a competitive edge in international and domestic markets. The development of LINX activities are occurred with the guidance and input of a communications sub-committee of representatives from the region's port authorities, railroads, freight forwarders, ocean carriers, terminal operators, and other interested parties.

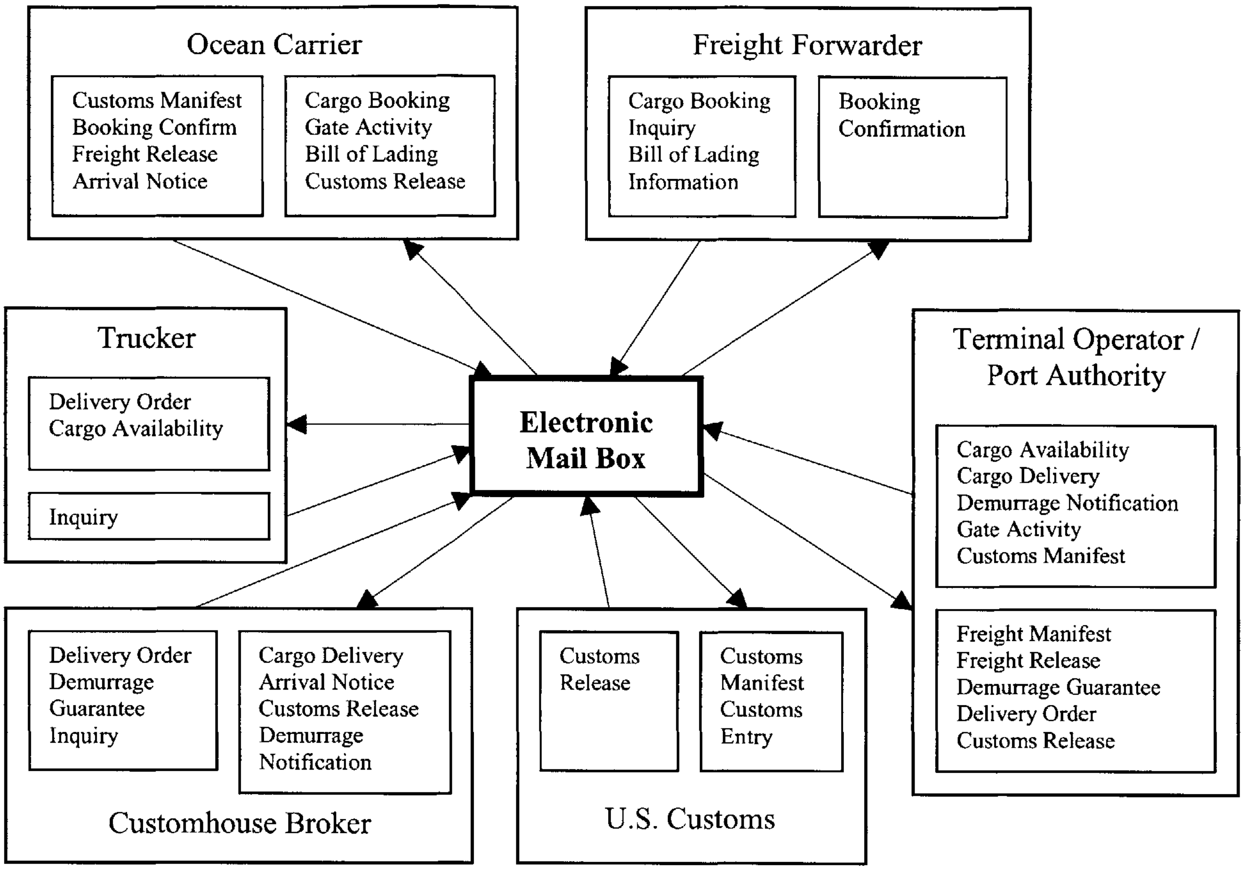


Figure 4-5 Automated Cargo Expediting System (ACES) in Port of New York and New Jersey[28]

EDI Systems for Intermodal Movement in the U.S.

The container shipping industry in the U.S. has successfully developed the EDI systems for intermodal container transportation. Particularly, railroad companies led the way in EDI use because so much of its traffic is handled by more than one railroad. Following the issuance of the TDCC standards for carrier-related activities, the Association of American Railroads (AAR) created Railinc in 1981 as a wholly-owned, for-profit subsidiary. Railinc aimed to provide the rail industry with seamless EDI service to make the industry more competitive and efficient.

[28] Muller, G. (1999), p. 291.

Railroads are using EDI in many applications, including bill of lading, shipment status, equipment and cargo weights, yard management, waybill retrieval, freight claim submissions, interline tracing, rate requests, logistics costs evaluation, fleet management, and other modules to meet specific customer needs[29]. EDI allows railroad companies to sharply improve performance, enabling them to offer the seamless service to their intermodal customers, which are ocean container carriers or freight forwarders. EDI permits timely and accurate billing, enabling customers to access information with only a phone call.

Like the rail industry, EDI also provides trucking companies with the ability to improve the services offered to customers. In particular, the trucking industry's use of EDI has been encouraged by large retailers and manufacturers who introduced just-in-time (JIT) inventory management strategies. Trucking companies are increasingly using EDI to submit invoices and bills of lading, saving money by eliminating manual keyboarding of information and improving equipment utilization. In case of intermodalism, truckers have become closely linked partners with railroad companies as well as ocean carriers by synthesizing their respective communication systems to improve service for their customers.

EDI Systems of Ocean Container Carriers in the U.S.

Major ocean container carriers serving in the U.S. have developed the EDI networks since the mid 1980s[30]. Direct EDI connections to the selected large shippers, freight forwarders, and terminal operators became active in the early 1990s. Among the many business transactions used for EDI, the shipment status for tracking the container location is the most widely used business transaction for EDI.

In addition, the business transactions for imports to the U.S. began to be widely used for EDI transactions in the early 1990s after the U.S. Customs announced the EDIFACT-

[29] *Ibid.*, p. 287.
[30] The information on the EDI systems of ocean container carriers in the U.S. is based on an interview with Connie Mead, Director of EDI at Log-net, on April 10, 2002.

based EDI system in 1988. Many carriers have implemented the EDI networks with shippers, freight forwarders, customs brokers, and terminal operators to distribute the customs-related documents for import in accordance with the customs proprietary format. For example, the ocean container carriers issue an electronic U.S. Customs manifest, showing the exact vessel contents for each importer with a shipment on board. Then, the ocean container carrier, the steamship agent, customs brokers, or NVOCC send the manifest to the U.S. Customs Service. Meanwhile, the EDI networks for export have recently been implemented since the late 1990s and are not as popular as the EDI networks for imports.

Besides the EDI connections with shippers and terminal operators, carriers have also developed the inter-carrier EDI networks in the mid 1990s. Through the inter-carrier EDI networks, carriers share the information on gate activity, booking transactions, shipment status, and so forth. The inter-carrier EDI networks became more important recently as many carriers have established alliances or vessel sharing agreements since the mid 1990s.

Unlike the EDI systems in Asian countries, where the governments have been pushing the adoption of EDI, the EDI systems of ocean container carriers in the U.S. have been driven by the customers' demand for EDI. Hence, the evolution of the EDI system of ocean container carriers in the U.S. has been slow and gradual for more than 20 years. In addition, despite the widespread awareness of EDI, only large shippers and freight forwarders are connected to the large ocean container carriers through the EDI systems. The shippers of small and medium enterprises (SMEs) generally do not implement the EDI systems with carriers.

4.3.2.5 The European Case

The container shipping industry in Europe has also developed EDI networks since the late 1970s and the early 1980s. Unlike the U.S. and Asian countries, port authorities played a leadership role in implementing most EDI projects in Europe. Ports of Bremen and Bremerhaven are the first example of implementing the EDI networks in Europe[31]. Their port information system, COMPASS, was established in 1976 through the efforts of over 100 separate interested users of the ports of Bremen and Bremerhaven. COMPASS joined all institutions involved with exporting/importing goods via Bremen/Bremerhaven into an integrated information network around a central database.

COMPASS provided EDI connections for optimizing container handling, automobile exports, import distribution, and industrial project shipments. Access to these highly specialized services is through the telecommunication interface known as LOTSE (Logistic Tele-Service), an open system without hardware or software compatibility problems. LOTSE ensured compatibility at all levels of communication between trading partners between the mid 1970s and the mid 1980s.

Following the adoption of EDIFACT by the United Nations in 1987, ports of Bremen and Bremerhaven upgraded COMPASS into the Teleport Bremen based on EDIFACT standards. The Teleport Bremen offers a worldwide network of managed EDI for the port user community. Intelligent nodes for international communications have been established in strategically placed economic centers such as Singapore, providing smooth data/information interchange between business partners.

Besides the case of Bremen/Bremerhaven, other major ports in Europe have implemented EDI networks in the early 1980s. Table 4-4 summarized the selected examples of EDI systems in the European ports.

[31] Muller, G. (1999), p. 290.

Table 4-4 Selected EDI Systems in the European Ports[32]

Name (Start year)	Bodies Involved	Major Services	Purpose
DAKOSY (1982)	Port community, Hamburg	Mail box, Port-EDI, GDCS*, DGIS**, EDIFACT, Customs clearance	Data communication systems for the transport sector
ADEMAR+ (1983)	Port community, Le Havre	Mail box, Port-EDI, EDIFACT, Customs clearance	Exchange of information and documents for container cargoes among the operators of the Le Havre
FCPS (1984)	Maritime Cargo Processing, plc.	Mail box, DGIS, Inventory control, Customs clearance	To reduce clearance time for cargo in the seaport areas. Applied in Felixstowe plus 13 locations, including ports, ICDs, and airport.
INTIS (1985)	Port community, Rotterdam	Mail box, EDIFACT, GDCS, DGIS, Port-EDI, Customs clearance	Communications network and information structure in Rotterdam
SEAGHA (1986)	Port community, Antwerp	Mail box, EDIFACT, GDCS, DGIS, Port-EDI, Customs clearance	Belgian transport EDI system based on EDI network in the port of Antwerp

* GDCS: Global Data Communication System
** DGIS: Dangerous Goods Information System

4.3.3 The Level of EDI Diffusion in the Container Shipping Industry

As shown in the case studies above, the EDI systems have been implemented worldwide in the container shipping industry. Indeed, the container shipping industry was one of the forerunners among the EDI adopters. A next research question is how much EDI has been

[32] Adapted from Lee, *et al.* (2000), p. 135.

actually diffused in the container shipping industry. The answer to this question can be used for anticipating the potential diffusion dynamics of the internet-based business in the container shipping industry.

Answering the research question, however, is not an easy task. Although there are many articles explaining the individual EDI projects implemented in the container shipping industry, it is rare to find historical research investigating the actual level of EDI diffusion in the container shipping industry. In fact, there are only a couple of research projects on the level of EDI diffusion in the transportation industry in general (Bowman, 1994; Grant, 1995; Pfeiffer, 1992). It is difficult to derive the precise data on the level of EDI diffusion in the container shipping industry. Rather, only a qualitative estimation of the EDI diffusion in the container shipping industry might be feasible.

To overcome this difficulty, this research uses a two-fold process. First, the research projects on the level of EDI diffusion in the transportation industry are used for estimating the overall trends of the EDI diffusion in the container shipping industry. Then, the estimated results are reconfirmed by reviewing the case studies and interviewing industry experts.

As the first step, Table 4-5 is the summary of the level of the EDI diffusion in the transportation industry in general.

Table 4-5 Summary of Research on the Level of the EDI Diffusion in the Transportation Industry

Author	Summary
Rockwell (1999)	• Half of all companies shipping products internationally by ocean or air transportation use EDI.
Grant (1995)	• Transportation industry has used EDI on average for slightly more than five years as of 1995; i.e., EDI has been adopted in the transportation industry since around 1990. • Despite the widespread use of EDI, only a few large transportation companies have actively used EDI. • Average EDI trading partners per company in the transportation industry is 114, a figure considerably higher than the U.S. average of 65 trading partners per company. • Percentage of EDI-enabled trading partners in 1995 is 19% of total trading partners per company in the transportation company. This percentage is well below the U.S. average of 23% in 1995. • Percentage of documents sent via EDI in 1995 is 33% of total documents in the transportation industry, and the percentage will increase to 50% by 1998.
Bowman (1994)	• Only about 10% of ocean shippers are linked to their carriers electronically, although the biggest companies have adopted the technology enthusiastically.
Pfeiffer (1992)	• Logistics companies started the EDI linkages from 1986 on average.

Meanwhile, the case studies on the EDI systems in the container shipping industry explain the diffusion of EDI as follows:

- The diffusion of EDI in Asian countries has started from the mid 1990s and increased faster due to the well-defined EDIFACT standards and active guidance of the governments.

- EDI in the U.S. became widely accepted from the early 1990s. Particularly, the intermodal EDI is more advanced than other regions. However, the EDI adoption is limited to large companies.

- In Europe, port authorities have led the adoption of EDI since the mid 1980s. It is expected that EDI is widely used in the container shipping industry.

In addition, two industry experts also mentioned the level of diffusion of EDI in the container shipping industry during interviews:

- Hank Lavery (CEO of Lavery Logistics)

  "In the transportation industry, including the container shipping, the overall adoption of EDI might be less than 50%. Although EDI in the transportation industry has been adopted from the early 1990s, the penetration of EDI has been limited to the large carriers and shippers. Small and medium enterprises (SMEs) have been reluctant to adopt EDI unless they were forced to join the EDI networks by the powerful trading partners."[33]

- Connie Mead (Director of EDI at Log-net)

  "Since the early 1990s, only larger carriers and shippers began to adopt the EDI technology on a daily basis. SMEs were laggard in adopting the EDI, partly due to the high cost."[34]

In summary, the different research projects and comments on the EDI diffusion discussed above can lead to a qualitative estimate of the level of EDI diffusion in the container shipping industry. Although EDI started to be used as early as the mid 1970s in the U.S., it was not until the early 1990s that the container shipping industry widely adopted the

[33] This is based on the interview with Hank Lavery on April 5, 2002.
[34] This is based on the interview with Connie Mead on April 10, 2002.

EDI technology. However, EDI is still limited to the large carriers and shippers only, leaving behind SMEs due to the high implementation costs. Overall, the level of EDI diffusion in the container shipping industry is estimated as less than 50% in terms of active EDI-enabled trading partners. Figure 4-6 describes the estimated level of EDI diffusion in the container shipping industry.

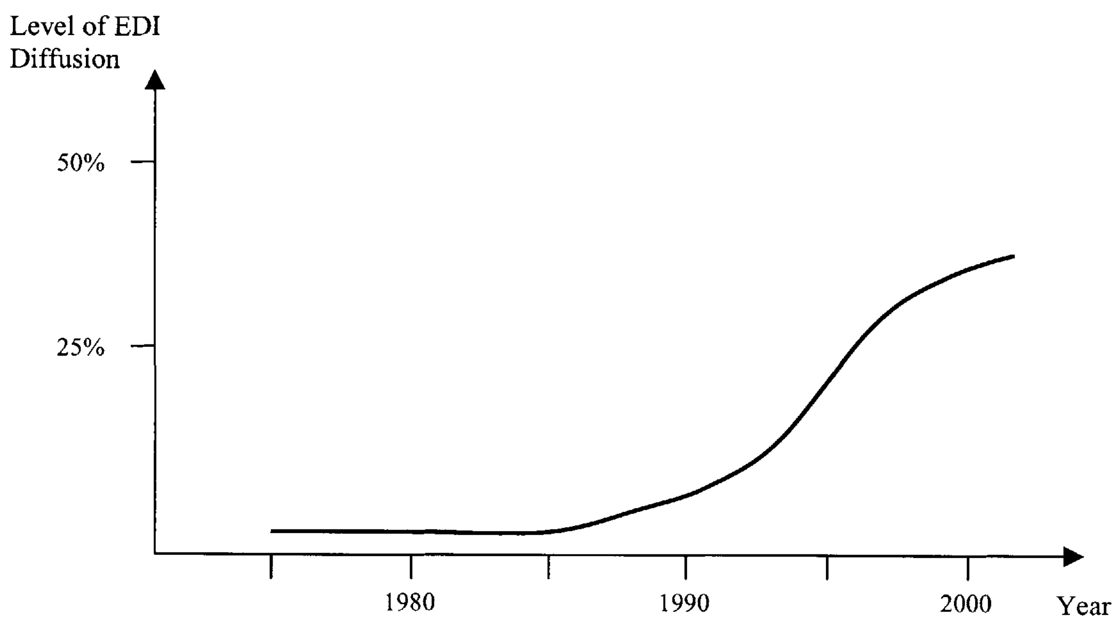


Figure 4-6 Level of EDI Diffusion in the Container Shipping Industry

4.3.4 Drivers and Inhibitors of the EDI Diffusion

The diffusion of EDI in the container shipping industry has been impacted by positive drivers and negative inhibitors. The drivers expedited the adoption of EDI by carriers and shippers while the inhibitors kept the players in the container shipping industry from implementing the EDI networks. Identifying the drivers and inhibitors facilitates the understanding of the diffusion dynamics of EDI in the container shipping industry and is useful for anticipating the potential diffusion of the internet-based business in the container shipping industry.

4.3.4.1 Drivers of the EDI Diffusion

In general, three drivers have helped the diffusion of EDI in the container shipping industry: standardization, customer demand with market power, and positive network externality from experience.

Standardization

As shown in Figure 4-6, it was not until the early 1990s that EDI began to be used widely in the container shipping industry. The main reason for such a wide acceptance is the establishment of the EDIFACT standards in 1987. The EDIFACT standards allow international trading partners to exchange trade and transportation documents through the EDI network. Before the EDIFACT standards, EDI has been implemented only within a industry or a country that shares the proprietary EDI standards. In the container shipping industry, which is by nature an international and cross-industry business, it is indispensable to use the common international standards for the EDI transactions. Thanks to the EDIFACT standards, the container shipping industry started to exchange the business transactions among the international trading partners through the EDI networks.

Customer Demand with Market Power

The second driver of the EDI diffusion in the container shipping industry is the customer demand with market power. In other words, a major driver of implementing the EDI networks by carriers is the demand for the EDI transactions by shippers who have strong market power. From the mid 1980s, the large manufacturing and retail companies, who are big customers of carriers, started to implement the Just-In-Time (JIT) inventory strategy. The JIT inventory strategy required more timely information on the shipments; EDI could provide more timely information on the status and location of cargo with little human intervention. Unless carriers could provide the EDI service, particularly to large shippers who preferred the JIT inventory strategy, carriers would fall behind in the severe competitive environments.

Empirical studies on the diffusion of EDI in the transportation industry supported this general trend. Pfeiffer (1992), Grant (1995), and Ferguson (1998) found that customer demand or request was the first reason why carriers adopted the EDI technology. In addition, a theoretical model for explaining the early adoption of EDI (Hart, *et al.* 1997) also emphasizes the importance of power in expediting the adoption of EDI.

Positive Network Externality from Experience

Together with the established EDI standards, positive network externality helps attract the new users of the EDI networks as the number of EDI users increases: As the number of EDI users increases, they are more experienced in the utilization and benefits of EDI so that they can persuade the non-EDI trading partners more effectively into joining the EDI networks.

In fact, the costs of adding trading partners and transaction sets into a EDI network have decreased as the industry becomes more experienced in EDI. According to the survey on EDI in the transportation industry (Grant, 1995), the cost of adding a new trading partner experienced in EDI is only $810 whereas the cost of adding a new trading partner doing EDI for the first time is as much as $1,263. Furthermore, the cost of adding a new transaction set with an existing trading partner is just $541. This positive network externality from experience improves the diffusion of EDI in the container shipping industry.

4.3.4.2 Inhibitors of the EDI Diffusion

Despite the potential benefits, EDI has not been well adopted by the SMEs in the container shipping industry. Three inhibitors might delay the diffusion of EDI in the container shipping industry: high cost of implementing EDI, lack of smooth integration with legacy computer systems, and cultural reliance on paper-based business transactions.

High Cost of Implementing EDI

The cost of implementing EDI has been prohibitively expensive to the small and medium companies. This high cost of implementing EDI was the main reason why the diffusion of EDI has been limited to the large companies. According to the survey on the EDI costs (Ferguson, 1998), the average yearly direct investment per company in EDI was $400,000 or more as of December 1997 to potentially be a leader in EDI and the company should maintain at least 2 full-time personnel to support the EDI implementation. In addition, in evaluating eight different costs of doing EDI between 1995 and 1997, the most significant cost was the initial setup. Overall, these costs of EDI implementation are too expensive for the SMEs.

Furthermore, introducing EDI requires business process reengineering (BPR) within the company to utilize EDI more effectively. So, the BPR entails another indirect costs of implementing EDI. This makes the EDI implementation more expensive than otherwise expected.

Lack of Smooth Integration with Legacy Computer Systems

Although EDI allows smooth exchange of business transactions among the trading partners, the success of EDI relies on the integration of EDI messages with internal legacy computer systems in a company. Because the legacy computer systems in a company were developed before EDI is actively used, they are sometimes not suitable for communicating with EDI messages, hence requiring expensive investment to establish the linkage between them. This hinders the further growth of the diffusion of EDI in the container shipping industry.

Cultural Reliance on Paper-based Business Transactions

While in theory EDI could eliminate any paper-based business transaction, companies in reality still prefer using the paper documents. A major reason for this persistent reliance on the paper is that the current legal system does not allow complete replacement of the paper documents with electronic documents. In one way or another, companies should keep the paper-based business transactions for legal purpose. This practice prohibits the substantial take-off of EDI in the container shipping industry.

4.3.5 Benefits of EDI in the Container Shipping Industry

As the level of the diffusion of EDI in the container shipping industry became mature, EDI provided benefits to this industry. The benefits of EDI in the container shipping industry can be divided into three categories: operational benefits, cultural benefits, and competitive benefits.

4.3.5.1 Operational Benefits of EDI

EDI provided several operational improvements to the container shipping industry. According to the survey (Grant, 1995), the transportation industry identified the five most substantial benefits of EDI: improved accuracy of data, reduced clerical errors, improved customer service, decreased administrative costs, and faster access to information. Among these benefits, the most important ones are improved data accuracy and reduced clerical errors. Before EDI, the transportation industry's error rate was that one in five documents contained an error. After EDI, error rates have fallen by 50%. Nonetheless, at a 10.3% error rate, the transportation industry continued to have the highest error rate of any industry group in the survey. Meanwhile, the transportation industry saw a 23% savings in the cost of processing an average document once EDI was implemented.

4.3.5.2 Cultural Benefits of EDI

EDI taught a new cultural lesson to the container shipping industry: *collaboration*. To develop the EDI networks, intimate collaborative work among the trading partners is essential. The container shipping industry should agree on the standards of the EDI communications, perfect the configuration of internal computer systems to smoothly flow the EDI messages, and more importantly, share the important operational information among the trading partners. Carriers, for example, must exchange the information on the location of containers with other inland transportation carriers, and also be tightly connected to the computers of manufacturing and retail companies to share the logistics-related information. The EDI implementation, therefore, emphasized the importance of collaboration to materialize the benefits from the new technologies.

4.3.5.3 Competitive Benefits of EDI

EDI has provided competitive advantages to the adopters of EDI. Once carriers establish the EDI connections, they can improve the customer lock-in, thereby improving revenues while reducing costs. This is why many companies decided to develop EDI in order to pursuer the related competitive advantages (Grant, 1995). Another EDI expert also confirmed that EDI has provided competitive benefits by increasing customer lock-in[35]. In addition, theoretical research on the impact of EDI shows that EDI will reduce the supplier base after implementing EDI by providing competitive advantages to the adopters of EDI (Wang, *et al.* 1995).

4.4 Interactions of EDI and the Internet-based Business

The internet technology has become available for business applications since 1998 and new internet-based business (e-business) models began offering various services to the container shipping industry. Having a similar technical origin, EDI and the internet will

[35] This is based on the interview with Hank Lavery, CEO of Lavery Logistics, on April 5, 2002.

be expected to interact with each other to develop new impacts on the industry. This section first compares the characteristics of EDI and the internet technology, and then discusses the potential interactions between EDI and the internet-based business in the container shipping industry.

4.4.1 Comparison of EDI and the Internet

There is no doubt that EDI has offered substantial benefits to the container shipping industry. EDI has improved the operational efficiency of the container shipping industry by providing more reliable and automatic communication networks than other traditional telecommunication technologies, e.g. telephone, fax, or telex. Carriers and shippers, who implemented EDI networks, have benefited from improved accuracy of data, reduced error rate, lower transaction costs, better customer service, and so forth.

EDI in the container shipping industry is now in the mature stage of technological evolution: The level of diffusion of EDI in the container shipping industry has stagnated at 50%. There have been no significant technological breakthroughs of the EDI technology in recent years. Reasons for the maturity of EDI are high implementation cost as well as closed and inflexible nature of the EDI system. In addition, the eroding competitive advantages from EDI due to the wide availability of EDI hinders faster diffusion of EDI in the container shipping industry. These characteristics limit the diffusion of EDI only to large carriers and shippers.

On the other hand, the internet has recently started and is a new telecommunication technology. The internet is more advanced than EDI in almost every aspect; it provides cheaper, more reliable, and more flexible telecommunication networks. Any company that has internet access with an internet browser can easily exchange business documents through the internet. The internet is an affordable telecommunication option for even SMEs due to the low implementation cost. Although the internet, unlike EDI, does not offer the machine-readable standard yet, it is developing a new machine-readable standard, or XML (Extensible Markup Language), for seamless exchange of business documents among different computer systems. Table 4-6 compares the characteristics of EDI and the internet technology in the container shipping industry.

Table 4-6 Comparison of EDI and the Internet Technology

EDI	Internet
• High implementation cost	• Low implementation cost
• Transaction focused	• Transaction and other value-added service are possible
• Closed system	• Open system
• Inflexible and rigid	• Flexible, resilient, and responsive
• Highly standardized and machine-readable format	• Developing standards, e.g. XML
• Limited to large companies	• Applicable to SMEs as well as large companies

EDI and the internet, however, share common characteristics. The most important common characteristic is that both EDI and the internet are network-based telecommunication technology, which is impacted by the network externality. The network externality tends to make the technologies follow a typical S-shaped technology curve as the number of the network users increases. In the early stage of the evolution of the network-based technology, the potential benefits from the network are so uncertain that the network size increases very slowly. It takes time to reach the critical mass of the network users, which allows the rapid diffusion of technology. This is called a "start-up problem" of the network-based technology. Once the network users exceed the critical mass point, they start to be impacted by the positive and negative network externality. On the positive side, the more the users of the network, the more benefits can be enjoyed by the network users from the size of the network. On the negative side, however, as the number of the network users increases, the perceived competitive advantages from the network become decreased, or commoditized, over time; thereby, the size of the network tends to stagnate. This negative dynamics is called a "stalling problem" of the network.

In summary, EDI in the container shipping industry has improved its performance since its first application in the early 1980s and shown an S-shaped technology curve. After arriving at the mature stage in the late 1990s, the EDI performance has leveled-off and is expected to remain stagnated in the future. However, in the late 1990s, the internet technology began to provide the container shipping industry with new performance, which is comparable to the current EDI capability. Like the EDI technology, the internet is expected to follow a similar S-shaped technology curve in the future.
Figure 4-7 shows this historical development of EDI and expected development of the internet technology in the container shipping industry.

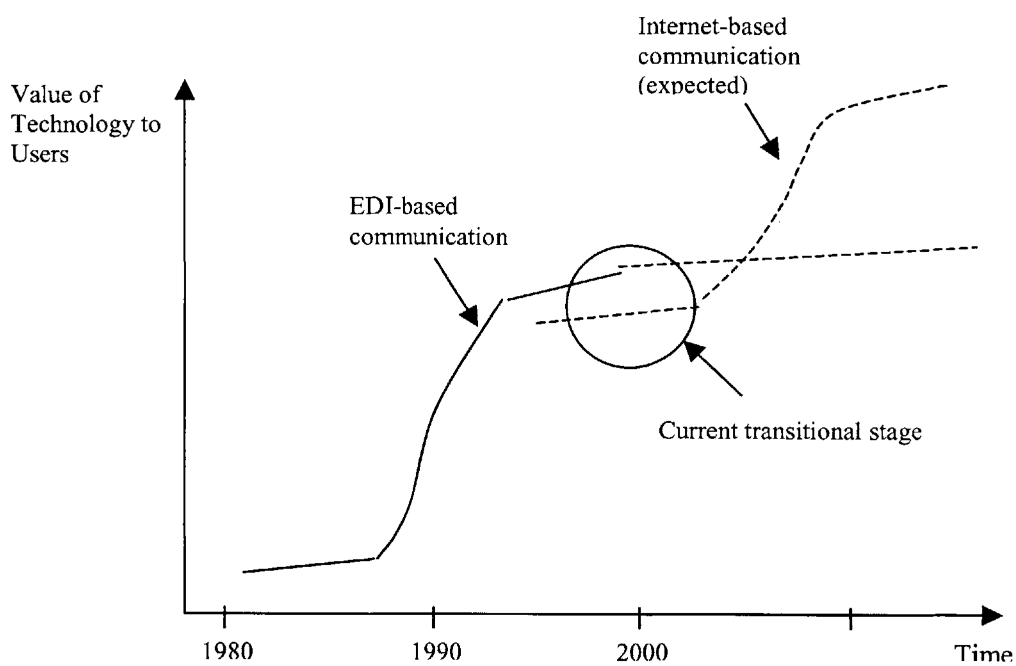


Figure 4-7 Technological Development of EDI and the Internet in the Container Shipping Industry

4.4.2 Potential Interactions between EDI and the Internet Technology

As discussed above, EDI and the internet technology are interacting with each other. They are in a transitional stage of technological evolution. Considering various comparative characteristics of EDI and the internet technology, the interactions between the two technologies will be expected to provide interesting impacts on the container shipping industry. Four potential interactions between EDI and the internet technology are anticipated.

- First, EDI will not disappear temporarily despite the wide popularity of the internet-based business; Rather, EDI will be transformed into a type of the internet-based business activities by utilizing the internet's cheaper telecommunication networks. In other words, as the internet becomes more popular and easily accessible, the majority of EDI transactions can be transmitted more cheaply, reliably, and faster. Therefore, EDI could be more diffused in the internet era. In fact, recent research shows that EDI traffic going through the web will increase by 20% over the next four year, with 80% of all EDI transactions supported by the internet in 10 years (Mitchell, 2002). Driving the movement is the lower cost of doing business via the internet. In addition, 72% of companies using EDI indicated that they plan to convert some EDI to XML at some point in the future (McGarr, M.S., 2001). Furthermore, given that EDI adopters have invested a substantial amount of money in EDI, they cannot scrap it completely, but will improve the efficiency of EDI using the internet technology.

- Second, reviewing the evolution of the EDI standards, standardization will be an important factor in determining the take-off of the diffusion of the internet-based business activities. In EDI, the establishment of the EDIFACT standards was the critical point that expedited the adoption of EDI in the container shipping industry. The well-defined standards allowed trading partners to develop the seamless EDI networks with less investment and time. Accordingly, developing a generally accepted internet standard for exchanging the business transactions, such as XML, is a prerequisite for the rapid diffusion of the internet-based business in the container shipping industry.

- Finally, it is necessary to overcome the "start-up problem" of the network in the internet-based business activities as in the EDI networks. To do this, collaboration among large carriers and shippers is important for the success of internet-based business activities in the container shipping industry. Reviewing the early success of EDI projects, the governments or large market players actively pushed the adoption of EDI among the trading partners by utilizing their market power. The active involvement of such market leaders expedited the arrival of the critical mass of users, which made the EDI network be more successful as soon as possible. Given that both EDI and the internet-based business are by nature network-based activities, the active role of powerful market players is an important factor for successful internet-based business activities.

4.5 Conclusions

This chapter analyzes the historical evolution of EDI in the container shipping industry and provides insights into the potential dynamics of the internet-based business activities in the container shipping industry. After reviewing the general information on EDI, detailed characteristics of the EDI diffusion in the container shipping industry have been investigated by comparing several EDI projects. The analysis reveals that EDI began to be actively used in the container shipping industry since the early 1990s thanks to the establishment of the well-defined international EDI standards, EDIFACT, in 1987.

Three drivers – standardization, customer demand with market power, and positive network externality from experience – explain the rapid diffusion of EDI in the mid 1990s. Despite the rapid diffusion of EDI, the diffusion process has been retarded recently due to the three inhibitors: high cost of implementing EDI, lack of smooth integration with legacy computer systems, and cultural reliance on paper-based business transactions. EDI has been limited to large carriers and shippers in general, and the current level of EDI diffusion in the container shipping industry is estimated as less than 50% in terms of active EDI-enabled trading partners. The EDI adopters in the container shipping industry have enjoyed operational benefits, realized the importance of collaboration, and benefited from the competitive advantages by increasing customer lock-in.

Meanwhile, close comparison of EDI and the internet concludes that (1) EDI is expected to be gradually absorbed by the internet-based telecommunication networks; (2) the internet standards for exchanging business transactions should be a critical factor for the take-off of the internet-based business activities; and (3) active collaboration among large carriers and shippers could overcome the "start-up" problem of the network in the internet-based business activities, thereby expediting the diffusion of EDI in the container shipping industry. These insights into the potential interactions of EDI and the internet are useful for anticipating the potential diffusion dynamics of the internet-based business activities in the container shipping industry, which are analyzed in detail in the next chapter.

Chapter 5 E-Business in the Container Shipping Industry

5.1 Introduction

When internet-based business (e-business) activities began booming from the middle of 1998, the container shipping industry (CSI) was no exception in seeing numerous new internet-based business models. The e-business models in the container shipping industry have been growing significantly since mid-1999. More than 100 firms charged with new e-business models have been founded during the years of 1999 and 2000 in the CSI to utilize the potential benefits from the internet-based technologies. Each new venture has tried to penetrate the market with its own competitive strategy with unique technology settings. Surviving through the dot-com crash[36] in mid-2000, the e-business models in the CSI became an important driving force of the daily business activities in the CSI.

This chapter reviews and evaluates the e-business models in the container shipping industry. There are two sections in this chapter: The first section analyzes the current state of the art of e-business models in the CSI. Five different e-business models in the CSI are identified based on their service types. The general trends and characteristics of each e-business model in the CSI are carefully examined. Brief case studies of each e-business model are also presented. Based on the information in the first section, the second part of this chapter comparatively evaluates the e-business models in the CSI using three frameworks developed from a technology strategy perspective. This comparative analysis helps identify the most promising e-business models in the CSI.

[36] The timing of the dot-com crash is the 3rd quarter of 2000, i.e., from July to September 2000, when the technology stock market began nose-diving and drove many e-business companies to go bankrupt or change their business focus.

5.2 Characteristics of Internet-based Business Models in the Container Shipping Industry

The e-business models in the CSI can be divided into five different categories based on the service type they provide: portal, e-marketplace, collaborative tool provider (CTP), e-procurement service provider (e-PSP), and e-chartering service provider (e-CSP). Three of them – portal, e-marketplace, and the CTP – can be related to the value chain of service delivery of carriers, whereas the rest – e-PSP and e-CSP – can pertain to the value chain of asset management of carriers. In other words, the former is externally focused from carriers perspective while the latter is internally focused. Figure 5-1 shows this relationship.

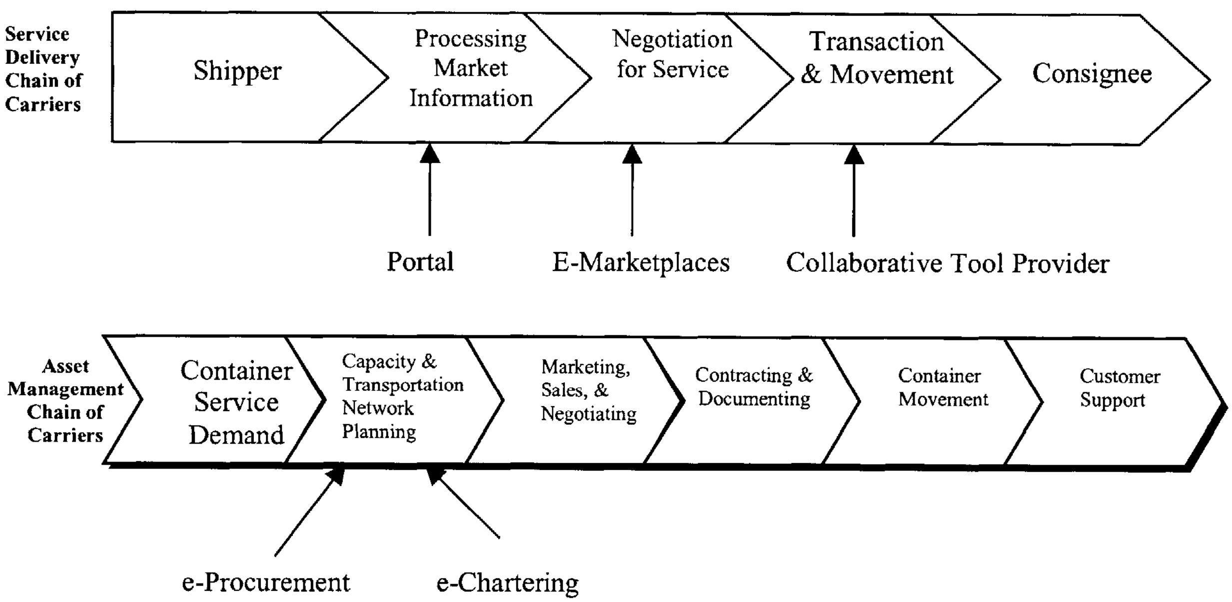


Figure 5-1 Value Chain and Internet-based Business Models of the Container Shipping Industry

Although these five e-business models are still alive despite the dot-com crash, the focus for each model has changed slightly. The following sections review the characteristics of each e-business model in the CSI, analyze how these models have changed before and after the dot-com crash, and present a brief case study for each e-business model.

5.2.1 Portal

Portals provide their customers with the market information that is crucial for the shippers and carriers to sign a contract for container movement. The major strategy of the portal service is to execute the following process: providing crucial market information for the industry, attracting members of the portal, building business community among the members, expediting business transactions among the members through the portal, and finally creating revenue and profits. In other words, they want to be a 'Yahoo!' for the container shipping industry. Examples include MaritimeDirect.com, Freightgate.com, GT Nexus, INTTRA, Cargo Smart, and so forth.

The revenue models of the portal are the subscription fees that the portal charges to the members, transaction fees for the business contracts among the members, and advertising revenue. The types of market information the portal provides are the freight rate along the trade routes, fuel price for operating the vessels, port-specific information, etc.

The weakness of this approach is that it does not guarantee profits. There are numerous "free" market information sources on the internet. If the free market information sources are easy to acquire and useful to understand the market, it is difficult to attract the members who are loyal to the portals. As long as the portals cannot attract the loyal users of their websites, it is impossible to build the business community, expedite business transactions, and create revenue and profits. Therefore, the key success factor of the portal is the ability to provide high quality market information that makes the users of the portal pay subscription fees to be members of the business community.

Before the dot-com crash, the portal was one of popular e-business models in the CSI. Every investor of the portal believed that the portal would capture the majority of the benefits from the internet-based business revolution. However, it turned out that it was very expensive to build a profitable portal site in the CSI. Moreover, the users of the portal were not loyal to the portal's service and just visited the portal's website to collect market information. Accordingly, many early portals in the CSI, for example, MaritimeDirect.com, went bankrupt in the middle of the dot-com crash.

Two reasons might have caused the failure of the early portals: First, the portal could not provide precious market information or contents that could gather the critical mass of users of the portals. In other words, the portals could not develop sufficient "liquidity" that should have enabled business contracts through their websites. Second, most of the portals lacked industry contacts to attract the users of their service because many founders of the portals were pure entrepreneurs with little container shipping experience. Many founders had backgrounds in consulting or investment banking as opposed to the container shipping industry. Thus, the portals failed to grab major ocean shipping companies as the loyal users of their website.

After the dot-com crash, noticing that pure portals without any industry support rarely succeed, new portals, or "carrier-oriented portals," were launched. Examples included GT Nexus, INTTRA, and Cargo Smart. A difference from the early portals is that the carrier-oriented portals have attracted several major container shipping companies as equity investors. By attracting the carriers as investors as well as customers, the carrier-oriented portals could increase the customer loyalty, credibility of their services, and financial strength, thereby increasing the possibility of being profitable in the long run. Another difference between the early portals and the carrier-oriented portals is that the carrier-oriented portals have tried to integrate the functions of the collaborative tool providers (CTPs). In other words, they have emphasized the functions of the collaboration between carriers and shippers by providing common platforms. Sometimes they have developed partnerships with the CTPs. These characteristics are examined in the case studies below.

Case Study: MaritimeDirect.com – An Early Portal

One example of the portal business model is MaritimeDirect.com, founded by a couple of wealthy ocean shipping businessmen in April 2000, right before the fall of NASDAQ. Although it was not clear how much investment was raised initially, it was then believed to be a promising portal in the CSI in terms of money and industry contacts. MaritimeDirect.com first offered basic ocean shipping related market information, such as industry-specific news, weather, port information, and general economic news. More importantly, the detailed port related information, such as ports' specifications, points of contacts, and so forth, was so unique at the time of its foundation that the information was hardly found in other portal sites. In general, the content of MaritimeDirect.com was excellent enough to attract the potential users of the portal.

MaritimeDirect.com, however, failed to transform the potential customers into real business contracts. By the end of 2000, MaritimeDirect.com could not provide any revenue-generating service on its website. It just burnt away its initially raised money. Furthermore, it even did not force the users to register, which is one of the basic tactics to track the users' information preference on the web contents. A pressured stock market from the 3rd quarter of 2000 to the 1st quarter of 2001 gave little help to such an e-business model without generating any profit. Despite the good financing and the resourceful industry contacts of the founders, MaritimeDirect.com finally went bankrupt in March 2001.

Case Study: GT Nexus – A Carrier-oriented Portal

GT Nexus, formerly known as Tradiant, was founded on March 27, 2000 by a couple of former IT (Information Technology) staff members from APL (American President Line), which is one of the largest container shipping companies. GT Nexus' primary vision was to provide efficiency and integration to the global supply chain. The management team is composed of entrepreneurs, IT experts, and container shipping industry veterans. Major founding investors include venture capital companies, nine large container shipping carriers, and a large trading company.

GT Nexus has two service types as of November 2001; "global planning series" and "global execution series," which are mainly targeted for the carriers' customer support. The global planning series provides not only basic market information to the registered users, such as news and freight rates, but also transportation planning tools, such as contract support module, business forecasting module, and optimal freight allocation module service. Meanwhile, the global execution series focuses on supporting actual container shipping management so that the series provides booking systems for shippers, documentation systems for managing transportation and trade documents across international carriers, a container tracking system, and reporting systems that identify trends and analyze data captured in the GT Nexus system. In summary, GT Nexus' product is a combination of the pure portal approach and collaborative tool provider's approach. It adopts an "evolutionary" approach in developing internet-based business with the container shipping industry by closely working with large incumbent ocean container carriers.

5.2.2 E-marketplace

E-marketplace provides a virtual meeting place for the buyers and sellers of container shipping services. At the virtual meeting place, the buyers and sellers can find the business partners, and make a business contract for the container shipping service. For example, the buyers post their service request on the e-marketplace, and then the sellers of the container shipping service bid for the contract. In same way, the sellers post their service offerings on the e-marketplace and then the buyers choose the service that is the most suitable for their business needs. In other words, the e-marketplace tries to build an efficient marketplace for the spot market[37] of the container shipping service.

[37] There are two types of markets in the container shipping industry based on the duration of service contract: spot market and long-term contract market. In the spot market, carriers and shippers make a contract on an as-needed basis (such as for a single voyage), whereas, in the long-term contract market,

The e-marketplace providers generate revenue by collecting transaction fees if a contract between the buyers and sellers is made. The fees could be a small portion of the total price of transaction. The e-marketplace is basically a new type of intermediary assisting the buyers and sellers to make a contract more efficiently through the internet-based technology. They want to be an "e-Bay" for the container shipping industry. Examples include the e-marketplaces for general container shipping service contract (e.g., GoCargo.com), container leasing and sharing (e.g., Interbox.com, Synchronet.com), and refrigerated container shipping service (e.g., GoReefers.com).

The critical success factor of e-marketplace is the "liquidity" : buyers and sellers can find sufficiently large numbers of business partners to meet their business requirements. For example, if the buyers cannot find many qualified sellers, the buyers will not join the e-marketplace, and vice versa.

Throughout the dot-com crash, several e-marketplaces, especially the ones for general container shipping service contract, went bankrupt. For example, GoCargo.com, which was one of the first e-marketplaces in the CSI, failed to generate enough revenue to sustain the operation and went bankrupt in March 2001. A main reason for its failure was that the auction service of the GoCargo.com was so focused on driving down the freight rate that major carriers refused to join the auction service, thereby reducing the liquidity of the e-marketplace. Only the e-marketplaces for container leasing/sharing and refrigerated container shipping service are still operating, though with very little profit. It remains to be seen if these e-marketplaces will be successful in the long term.

Case Study: GoCargo.com

GoCargo.com was founded on October 12, 1999 by an entrepreneur with consulting background with a vision of being the first business-to-business company in the container

carriers and shippers make a contract that is valid for a longer period of time (i.e., one year). The average market share of spot market is around 20% of the total market size.

shipping industry. It provides a dynamic auctioning platform where buyers and sellers of container shipping service do business online. In other words, it wanted to be an 'eBay' in the container shipping industry. More specifically, GoCargo.com adopts a reverse auction strategy that shippers (or buyers) post their service requirements and then carriers (or sellers) bid for the service requirements. At the end of bidding process, the lowest bidder wins the competition and the bidder (or carrier) and shipper make a business contract. GoCargo.com adopts a "revolutionary" approach in that it tries to apply a "stock-trading-type" of service into the container shipping industry. It is, unlike GT Nexus, really a shipper-oriented internet-based business model.

Major customers of GoCargo.com's service are small shippers and NVOCCs (Non-Vessel Operating Common Carriers), both of which are targeting the spot market of container shipping service. As of September 27, 2000, GoCargo.com claimed that its total membership exceeded 12,000 and cumulative transaction volume since its inception amounted to more than 5,000.

Major investors are leading investment banks and venture capital companies, such as Goldman Sachs, Atlas Ventures, and Seed Capital Partners. No incumbent industry players, however, have invested in this company. In addition, few industry veterans are seated in the management team.

Although it was successful during the first half of the year of 2000, it confronted tough market pressure from the carriers who dislike GoCargo.com's shipper-oriented auction model because the auction can erode the freight rates by shifting the market power from carriers to shippers. With a few exceptions, a majority of large carriers did not join the GoCargo.com's service. Only NVOCCs have provided their shipping capacity to GoCargo.com's auction market. In addition, the overall size of the spot market that GoCargo.com was tapping is relatively small compared with a long-term contract market, where carriers and shippers directly negotiate shipping contract on a yearly basis. The ratio of spot market size to the long-term contract market is estimated to be 2 to 8. Bewildered by this pressure, GoCargo.com launched a new internet-based platform in

February 2001, called NaviPact, which helps carriers and shippers negotiate long-term contracts online efficiently. Despite this effort to transform its business model from the spot market to the long-term contract market, GoCargo.com finally went bankrupt in March 2001.

5.2.3 Collaborative Tool Provider

Collaborative Tool Provider (CTP) offers the shippers and carriers the means to manage the container movement efficiently by integrating logistics information seamlessly among the inter-company computer systems. Among their service offerings are tracking container movement from the shipper to the consignee, generating and distributing internet-based trade documents for container movement across the business partners, and providing smooth customs clearance with less human involvement, calculating total landed cost for the transportation service. By using the CTP's service, the shippers and carriers can efficiently manage their logistics functions. Most CTPs develop special internet-based software for each specific function. They generate revenue by either selling the software, collecting licensing fees for the software, or charging subscription fees for using the internet-based service.

The CTPs can be divided into three types based on their business focus: First, a carrier-oriented CTP (c-CTP) offers internet-based transportation management software mainly for carriers. Examples of the c-CTP include Celarix, ShipLogix, CarrierPoint, Descarte, and so forth. The c-CTPs usually provide a fleet management tool, tracking and tracing of containers, tariff publishing tool, auctioning tool, and so on. The second type of the CTP is a shipper-oriented CTP (s-CTP). The s-CTPs offer internet-based logistics management software that can enhance the shippers' or transportation intermediaries' supply chain management capabilities. Their software provides the functions of managing different carriers efficiently, calculating total landed cost, checking trading regulations automatically, and so on. Examples of the s-CTPs' service are international trade management (e.g., Vastera, ClearCross), trade regulation and landed cost calculation (e.g., NextLinx), logistics management software (e.g., FreightDesk.com, Oceanwide, Rely

Software, G-Log), etc. The third type of the CTP is a niche player (n-CTP), which provides internet-based software for specific functions of the container shipping industry. The functions that the n-CTP's service offers include an internet-based international trade payment system (e.g., CCEWEB, TradeCard), an internet-based trading environment (e.g., Boleron.net), etc.

A critical success factor for the CTP is standardization. A basic function of the CTP's software is to connect the specific business information with current company-wide computer system. So, if the CTP's product does not follow the industry standard, it will not be successful.

Case Study: FreightDesk.com

FreightDesk.com was founded on March 10, 2000 by Rob Quartel, who was a former commissioner of Federal Maritime Commission (FMC) in the U.S. It attempts to help transportation intermediaries, e.g., freight forwarder and customs brokers, improve their transportation management work by using its internet-based collaborative transportation management tools. Its first product, called FreightDeskPro, is a comprehensive internet-based system that automates and simplifies the entire process of managing international shipments from purchase order to delivery confirmation. FreightDesk.com also offers tracking capability for the users of its collaborative tools. Its revenue model is a transaction-based approach, not subscription-based one, so that users only pay as much as they use FreightDesk.com's service.

FreightDesk.com has a clear market entry strategy that focuses on freight forwarders, which in general lack IT capability despite the urgent need. It likes to be called an "IT department for transportation intermediaries[38]." Accordingly, its technical approach is not revolutionary, but "evolutionary."

[38] Private interview with FreightDesk CEO Rob Quartel on March 16, 2001

Unlike GT Nexus and GoCargo.com, most investors in FreightDesk.com are individuals, not institutional investors, so that its investors' list is not publicly available. The management team is generally composed of entrepreneurs with IT industry background, but it has a few industry veterans.

5.2.4 E-procurement Service Provider (e-PSP)

E-procurement service provider (e-PSP) offers internet-based trading platforms for carriers to buy ship management-related parts and service – called "ship supplies[39]" – from the ship suppliers. In other words, the e-PSP tries to automate the purchasing of ship supplies for carriers by either hosting internet-based auction systems or providing business negotiation tools.

In general, the ship supplies market is relatively well positioned to attract the e-PSPs. First, the ship supplies market size is huge. Total ship supplies market size in 1998 was $4.2 billion and the containerships provided $792 million[40], which is almost 20% of total ship supplies market size. In addition to the huge market size, the ship suppliers are so fragmented and geographically dispersed that the value of an internet-based information service, which provides efficient information flow among the market participants, could be substantial. Moreover, since the ship supplies have very different specifications, it is critical for carriers to maintain the information of their ship parts for efficient ship maintenance.

Given this market attractiveness, several e-PSPs were founded targeting the ship supplies market before the dot-com crash, and they have been relatively sustainable even after the dot-com crash. One e-PSP has shown positive cash flow from its operation, which is quite impressive for an e-business company[41]. The examples of the e-PSPs include

[39] For example, the ship supplies include bunker, lubricants, cabin stores and waters, general stores, spares, victualling, etc

[40] Booz Allen & Hamilton, (1998), "Strategy Summary on Setfair.com Project,"

[41] According to the DigitalShip.com's article on August 27th, 2001, SmartSpares.com reported that it was cash flow positive.

OneSea.com, PrimeSupplier.com Arena.com, E4Marine.com, MarineProvider.com, Smart Spares, OceanConnect.com, etc.

Case Study: OneSea.com (or SeaSupplier.com)

OneSea.com was founded in early 1999, when many other e-business companies in the CSI were launched. One of the original founding members was Maersk (now Maersk Sealand), the largest container shipping company, and other founding members included well-known Norwegian ship owners and managers, such as V-Ships, Acomarit, Bergesen, Teekay, Jebsen, Hoegh, etc. OneSea.com, collaborating with Computer Associates, developed an online auction system, online catalogues, and customer profiling systems, to expedite the internet-based procurement of ship supplies.

A major strength of OneSea.com, compared to other e-PSPs, was that it had lured many major industry players as founding investors. This collaborating effort could provide the liquidity to OneSea.com's e-procurement platform. In addition, the support from the industry players made OneSea.com be more active in M&A (merger and acquisition) deals with other e-PSPs by utilizing broad industry contacts from the founding member companies. After a series of M&A deals with smaller e-PSPs, OneSea.com finally became merged with PrimeSupplier.com, a formidable e-PSP competitor backed by another industry giant, Stolt-Nielsen, in May 2001, renaming itself SeaSupplier.com.

5.2.5 E-chartering Service Provider (e-CSP)

An e-chartering service provider (e-CSP) specializes in connecting the ship owners and charterers, who rent the ships for operation. Historically, the ship chartering business has been a relationship-based activity so that a trusted 3rd party, or the ship broker, has controlled the ship chartering market. The ship brokers develop a database on up-to-date ship-related information, maintain good relationships with ship owners and charterers, and play the brokerage role in ship chartering. Given the globe-wide nature of the container shipping industry and complex ship specifications, the ship brokers have played an important role in ship chartering.

In the wake of the internet boom in 2000, however, several new e-CSPs were launched to capture this ship chartering market and they are generally in the early stages of business development. The e-CSPs provide useful ship chartering related information and online negotiation tools for ship owners and charters. The benefit to carriers of using the e-CSP service is that it can reduce the information search cost, which has been awarded to the ship brokers, to find out the right ship owners and charterers to make a ship chartering contract. Despite its potential benefits to ship owners and charterers, it remains to be seen whether or not the e-CSPs can overcome the traditional relationship-based nature of the ship chartering market.

The examples of the e-CSPs include LevelSeas.com, Shipbrokering.com, Slotcharter.com, ShipIQ.com, and Shipping-direct.com.

Case Study: LevelSeas.com

LevelSeas.com was founded in April 2000 to provide internet-based ship chartering service to the ocean shipping community. The founding shareholders were venture capitalists and charterers of tanker or bulk ships such as Shell, BP, and Cargill; however, a ship broker, Clarksons, and bulk shipping companies, such as Maersk, Bergensen, OMI, Teekay, and V Ships, later joined the company as shareholders. LevelSeas.com now has 34 ocean shipping related companies, including major charters, owners, and brokers, as shareholders.

LevelSeas.com's product is designed to make ship chartering activities more efficient through the internet-based communication technology. Its first internet-based chartering product, called LSX 1.0, was launched in July 2001 and enable owners, charterers, and brokers to trade, communicate, and manage market information online. Its second version, LSX 2.0, which was launched in September 2001, provides contract negotiation, questionnaire and charter party editing functionality, and a button to actually complete a ship chartering transaction.[42]

The revenue model of LevelSeas.com is to charge a mixture of subscription fees and transaction commission, which is expected be 0.5% of the value of a transaction conducted through its website (up to $20,000 per transaction).

A major competitive advantage of LevelSeas.com over other e-CSPs is to attract diverse industry players in ship chartering market as shareholders. The strong support from the industry players could potentially increase the liquidity of its e-chartering marketplace so that its operation can be profitable as soon as possible. However, LevelSeas.com might have to overcome two strategic challenges to be successful: First, none of the players – charterers, owners, or brokers – in the ship chartering market are yet ready to pay the transaction commission although they are willing to become subscribers to the LevelSeas.com's service. LevelSeas.com should deal with this uncertainty of its revenue source. Second, the strong presence of traditional ship brokers in the ship chartering market might limit the success of LevelSeas.com. Still, many ship brokers did not join the LevelSeas.com's service for fear of losing ship brokerage business: they worry about potential disintermediation of the ship chartering market. Given that the ocean shipping industry has been very old and fairly fragmented, the role of ship brokers cannot be ignored. Therefore, to develop the right strategic partnership with traditional ship brokers is crucial to the success of LevelSeas.com in the future.

5.2.6 Summary

This section has analyzed the characteristics of internet-based business models in the CSI. Table 5-1 shows a general overview of e-business models in the CSI.

[42] Digital Ship, (2001), "Latest in online chartering," July/August 2001, p. 23.

Table 5-1 General Overview of internet-based business activities in the CSI

	e- Business Models						
	Portal	e-Marketplace	Collaborative Tool Provider (CTP)			e-Procurement	e-Chartering
			c-CTP	s-CTP	n-CTP		
Players	MaritimeDirect	GoCargo.com	Celarix	Vastera	CCEWEB	SeaSupplier.com	LevelSeas.com
	Freightgate.com	GoReefers.com	ShipLogix	ClearCross	TradeCard	OceanConnect	Shipbrokering
			CarrierPoint	NextLinx		Bunkerworld.com	Slotcharter.com
	GT Nexus	Interbox.com	Descarte		Bolero.net	MarineProvider	ShipIQ.com
	INTTRA.com	Synchronet.com		FreightDesk		Smart Spares	Shipping-Direct
	CargoSmart.com			Oceanwide		ShipServe.com	
				Rely Software		iShipExange.com	

It is clear from this analysis that those e-business models have tried to change the basic dynamics of the CSI although some models have not been successful so far. Several notable conclusions can be drawn from this analysis.

- The boundary of each e-business model becomes blurry over time. For example, the early portals only focused on providing useful market information to attract the potential users, without supplementing the service with other sophisticated transportation management tools that the CTPs have usually tried to offer. However, realizing that the early portal model was not successful in amassing the critical volume of loyal users of its portal service, many recent portals, such as GT Nexus, INTTRA.com, and CargoSmart.com, also provide various collaborative tools. In addition, the portals and the CTPs even developed close partnerships to supplement their weaknesses. For example, GT Nexus, which is a carrier-oriented portal, and NextLinx, which provides regulatory contents and trade compliance software, formalized their strategic partnership in August 2001.

- Consolidation among the e-business companies in the CSI will be more active in the near future. Throughout the dot-com crash, many e-business companies went bust due to either unproven business models or weak financial support from investors. The e-business companies with more market-friendly strategies and financial strength will develop more merger-and-acquisition (M&A) deals to fortify their competitive positions.

- After the dot-com crash, it seems that the e-business models that are more "friendly" to major industry players, such as large carriers and shippers, will be sustained in the long run. For example, the early portals, which had little industry support, have failed, whereas the carrier-oriented portals receiving direct support from major carriers, such as GT Nexus and INTTRA.com, showed relatively sustaining operations despite the dot-com crash. Furthermore, the majority of the CTPs, which provide operational efficiency to major carriers and shippers, have managed to survive so far.

- Traditional business relationships in the CSI are so strong that it is difficult to revolutionize the current business practices with internet-based technology. For example, GoCargo.com, which tried to totally change the way of doing business in the CSI by tapping an internet-based auction system, failed to survive because the majority of carriers and shippers prefer the long-term contract market, which is mainly based on business relationships and quality of service, as opposed to price itself. Thus, the e-business models that can honor current business practices, such as the CTPs, are more likely to succeed in the long run.

5.3 Comparative Evaluation of Internet-based Business Models in the Container Shipping Industry

Each e-business model in the container shipping industry has its unique strengths and weaknesses. Given the market information discussed in the previous section, it is necessary to do a comparative analysis of these e-business models in the CSI. The comparative analysis can explain the reasons why many e-business models have failed, provide an insight into which e-business models are more likely to survive in the long run, and thus aid in understanding the potential impacts from e-business activities on the container shipping industry.

Three frameworks are proposed from a technology strategy perspective and used to comparatively evaluate the potential success of different e-business models in the container shipping industry : the "Appropriability – Complementary Assets" (A-CA) framework, the "Network Externality – Customer Lock-in" (NE-CL) framework, and the "Market Type – Customer Focus" (MT-CF)" framework. Each framework is specifically designed to identify the e-business models that are more likely to succeed in a given market environment. The A-CA framework provides a short-term success possibility for technology-oriented new ventures and helps them develop alliance strategies. Meanwhile, the NE-CL framework presents long-term success potential for technology-oriented new ventures. Finally, the MT-CF framework is useful for evaluating the internet-based marketplaces.

5.3.1 Evaluation Using the "Appropriability – Complementary Assets" (A-CA) Framework

5.3.1.1 "Appropriability – Complementary Assets" (A-CA) Framework

As Teece (1987) has argued, there are four different strategic playing fields for technology-oriented new ventures, based on two variables: level of appropriability and availability of complementary assets (Figure 5-2). Appropriability is the extent to which the technology expertise of ventures is protected either by intellectual property rights such as patents and trade secrecy, or by technical complexity that is difficult to copy. In the real world, the appropriability can be strong or weak. For example, Coca-Cola maintains strong appropriability for its cola formula by keeping it as a trade secret; whereas internet-based auction technology has weak appropriability due to its low technical complexity. Meanwhile, complementary assets are the resources that support the successful deployment of new technology, such as distribution channels, sales force, brand, reputation, manufacturing expertise, supplier exclusivity, and so on. In general, the complementary assets are freely available – i.e., tightly held by the technology-oriented ventures themselves – or tightly held by other players. For instance, in the early stage of the internet portal market, the complementary assets such as brand, distribution channels, or sales force were freely available because no one had ever owned them whereas in a sophisticated medical equipment (e.g., CT scanner) market, the complementary assets were tightly held by incumbent major players like GE.

A major benefit from the A-CA framework is that it is useful for understanding the short-term success possibilities of technology-oriented new ventures and for developing alliance strategies for them. For example, among the four strategic playing fields in the A-CA framework, a strategic alliance is more likely to be useful in the field of strong appropriability with complementary assets being tightly held by others (location (1) in Figure 5-2). In this field, a new venture has a strong technological capability that looks very attractive to potential alliance partners, while it lacks important complementary assets that are tightly controlled by other companies. Consequently, the company in the field (1) had better develop strategic alliances with other companies to improve its competitiveness, and the alliances will also be successful for the alliance partners.

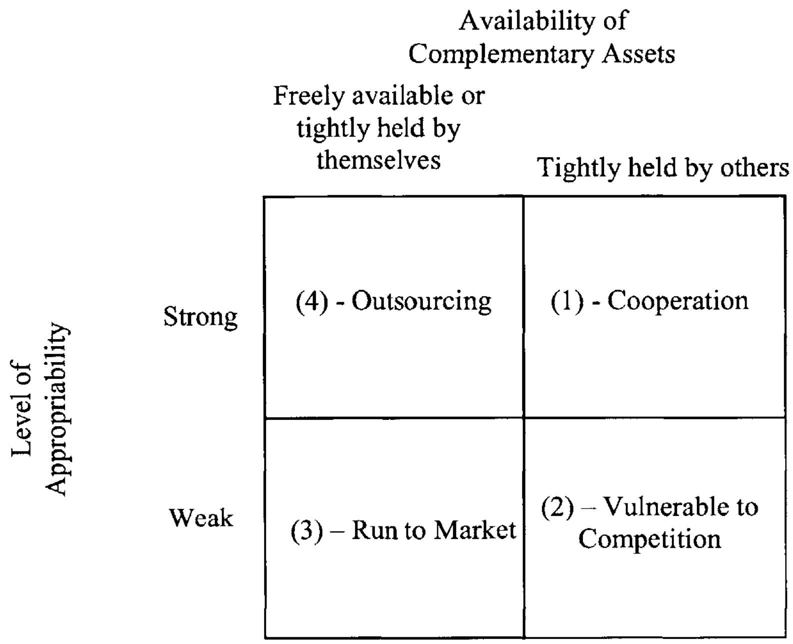


Figure 5-2 "Appropriability – Complementary Assets" Framework and Alliance Strategies

However, a company in the field (2) is most vulnerable to competition and least able to develop alliances with other companies since the company has neither a technological advantage nor important complementary assets. A new venture in the field (2), therefore, should either fortify appropriability through aggressive internal R&D efforts or develop strong alliances with complementary asset owners.

On the other hand, a company in the field (3) in Figure 5-2 had better pursue a stand-alone strategy to enter the market as soon as possible, because the market is freely open to new entrants and no company has yet dominated the market. In this case, the first company to enter the market and build tight control of complementary assets will be more likely to succeed. In contrast, a new venture in the field (4) will tend to outsource some complementary assets to other companies because the venture controls technological advantages with strong appropriability and can easily leverage the strong appropriability to develop outsourcing partnerships.

5.3.1.2 Evaluation of e-Businesses in the Container Shipping Industry with the A-CA Framework

Figure 5-3 shows the overall evaluation of six e-business models in the container shipping industry using the A-CA framework.[43]

Level of Appropriability \ Availability of Complementary Assets	Freely available or tightly held by themselves	Tightly held by others
Strong		CTP
Weak	Carrier Portal	Early Portal e-Marketplace e-PSP e-CSP

Figure 5-3 Application of "Appropriability – Complementary Assets" Framework to e-Business Models in the Container Shipping Industry

First of all, most e-business models in the CSI except the carrier-oriented portals have to deal with complementary assets tightly held by others. The CTPs, early portals, e-marketplaces, e-PSPs, and e-CSPs do not own sufficient complementary assets – e.g., established brand image, reputation, efficient sales force, and distribution channel – since they are small technology-oriented new ventures. For example, those companies have little brand recognition from the buyers and sellers of container shipping service, who are the core customers of e-marketplaces. Without knowing reliable brands, few customers are willing to join the e-marketplace. Having fewer customers lowers the liquidity of the

[43] The early portal and carrier-oriented portal are separately analyzed because they have different characteristics from the perspective of A-CA framework.

e-marketplace, making profitability elusive. In addition, because their business models are trying to change current business practices among incumbent players who have strong relationships, they cannot avoid collaborating with incumbent players to some extent. Therefore, all e-business models except the carrier-oriented portals have to compete in a field where complementary assets are tightly held by other companies.

Meanwhile, the carrier-oriented portals hold complementary assets that help them execute their business model successfully. In other words, because the carrier-oriented portals, such as GT Nexus, INTTRA, and CargoSmart.com, have several large container carriers as founding shareholders, the carrier-oriented portals can easily build their brand recognition and distribution channels, thereby establishing close relationships with major incumbent industry players.

On the other hand, on the dimension of the level of appropriability, only the CTPs have strong appropriability, whereas for the others it is weak. The CTPs are providing proprietary internet-based software that helps carriers support customers better or helps transportation intermediaries better manage the international cargo shipments. Their products are process-specific, so that it is difficult for other competitors to copy them in a short period of time. In other words, technological complexity itself provides relatively strong appropriability. In contrast, the software, which portals, e-marketplaces, e-PSPs, and e-CSPs are offering, can be easily customized from off-the-shelf internet-based platforms. For example, the function of matching buyers and sellers online without considering qualitative factors can be easily developed using the auctioning software for commodity products such as oil, natural gas, or stocks.

This analysis provides two important insights into the e-business models in the CSI: First, the analysis shows which e-business models are more likely to survive in the early stage of market entry. Comparing Figure 5-2 and Figure 5-3, the e-business models located in the field of weak appropriability and complementary assets being held by others, such as early portals, e-marketplaces, e-PSPs, and e-CSPs, are vulnerable to competition and thus less likely to survive. The demise of MaritimeDirect.com, an early portal, and

GoCargo.com, an e-marketplace, confirms the vulnerability of these e-business models. However, the CTPs and carrier-oriented portals are more likely to survive in the early stage of market entry than others, because the CTPs have strong appropriability and the carrier-oriented portals tightly control the complementary assets. As long as the CTPs and carrier-oriented portals supplement their strategic weaknesses, they can be successful new service providers for the container shipping industry.

This application of the A-CA framework provides another insight into developing alliance strategies for the e-business models in the CSI. Comparing Figure 5-2 and Figure 5-3, the CTPs should cooperate with the owners of complementary assets to realize their technological advantages. Unless the CTPs receive support from the owners of complementary assets, who are mostly major incumbent carriers, shippers, and intermediaries in the CSI, they cannot sell their proprietary software to the incumbents successfully. In addition, the comparison between Figure 5-2 and Figure 5-3 indicates that the carrier-oriented portals should enter the potential market as soon as possible before other competitors develop the ownership of complementary assets or launch technically superior software.

Table 5-2 and Figure 5-4 below further explain the potential alliance strategies for e-business models in the CSI from the A-CA framework. Another two-by-two matrix for developing alliance strategies can be proposed from the A-CA framework based on two dimensions: level of alliance needs and level of alliance implementability. The level of alliance needs is determined by the locations within the A-CA framework. For example, since the early portals, e-marketplaces, e-PSPs, and e-CSPs are located in the field (2) of the A-CA framework, it is most "urgent" to develop strategic alliances with strong owners of complementary assets in order to survive. Otherwise those e-business models in the field (2) of the A-CA framework will fail because of weak appropriability and no control of complementary assets. Meanwhile, because the CTPs are in the field (1) of the A-CA framework, where cooperation with owners of complementary assets is valuable for potential success, having strategic alliances is a necessary condition for their strategic developments. In addition, the carrier-oriented portals may need strategic alliances to enter the market as soon as possible, but the alliance developments are not urgent as long as the carrier-oriented portals have enough relationships with current industry players. Accordingly, the strategic alliances for the carrier-oriented portals can be a necessary condition for their strategic developments.

The level of alliance implementability, on the other hand, can be determined based on the strategic capabilities of e-business models. In other words, the higher level of appropriability a company has, the greater the possibility of alliance formation (Eisenhardt and Schoonhoven, 1996). Additionally, if a company can control the complementary assets tightly, it can easily develop strategic alliances with others who do not own complementary assets. Therefore, the CTPs and carrier-oriented portals can easily develop strategic alliances, thanks to their higher level of appropriability or tight ownership of complementary assets; whereas the remaining e-business models may have trouble in implementing strategic alliances because of their low level of appropriability.

Table 5-2 Application of "Appropriability – Complementary Assets" Framework and its Implication for Alliance Formation in e-Business Models in the Container Shipping Industry

	CTP	Carrier Portal	Others
Level of Appropriability	Strong	Weak	Weak
Availability of Complementary Assets	Tightly held by others	Freely available or tightly held by themselves	Tightly held by others
Level of Alliance Needs	Necessary	Necessary	Urgent
Level of Alliance Implementability	Easy	Easy	Difficult
Expected Strategic Alliance Formation	Highly likely	Highly likely	Likely but difficult

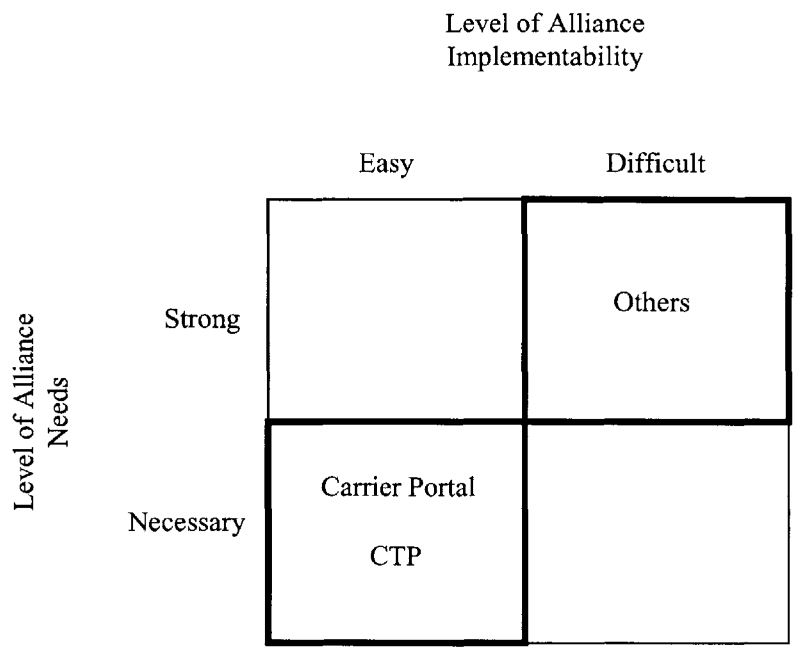


Figure 5-4 Potential Relationship between Alliance Needs and Alliance Implementability of e-Business Models in the Container Shipping Industry

Additionally, Figure 5-4 hints at another potential dynamic in e-business models in the CSI; The CTPs and carrier-oriented portals seem more likely to develop strategic alliances together, because the CTPs need to partner with someone who owns complementary assets and the carrier-oriented portals possess complementary assets. Alternately, the carrier-oriented portals should increase the appropriability of their technical service whereas the CTPs offer proprietary software that can supplement the service of the carrier-oriented portals. In reality, the CTPs and carrier-oriented portals have developed several strategic alliances. For example, GT Nexus developed a strategic alliance with NextLinx, which provides internet-based software to calculate total landed cost automatically, and INTTRA partnered with Vastera to provide international trade management service for shippers.

5.3.2 Evaluation Using the "Network Externality – Customer Lock-in" (NE-CL) Framework

5.3.2.1 "Network Externality – Customer Lock-in" (NE-CL) Framework

Internet-based businesses are by nature network-oriented activities. Any e-business model should attract potential users of its internet-based service, develop a community of users, drive business interactions among the users, and finally generate profits from the business interactions among the users. Consequently, network-related factors, such as network externality and customer lock-in, are critical in evaluating the e-business models.

Network externality (NE) is the extent that the size of network, or the number of users of network-oriented service, can impact the benefits of users themselves. If the benefits of users of network-oriented service increase as the number of users increases, the service has positive network externality. Conversely, if the benefits of users of network-oriented service decrease as the number of users increases, the service has negative network externality. For example, e-marketplace in the CSI can have positive network externality if sellers of container shipping service can find potential buyers more easily as the number of users of e-marketplace increases, and vice versa. In contrast, e-marketplace will suffer from negative network externality if sellers must spend more time to find the appropriate buyers as the number of users of e-marketplace increases.

On the other hand, customer lock-in (CL) is the extent that customers will stick to current service. The more attractive the current service is, the more strongly the customer will be locked in to the current service. The customer lock-in, particularly of technology-based service, is affected by switching costs and standards. In other words, if switching costs, which customers pay for changing the service from one to another, are high, the customer lock-in to current service will increase, and vice versa. In addition, if the standards are well established among the customers, the customers are more likely to stick to their current service.

The combination of network externality and customer lock-in provides a useful framework of a two-by-two matrix (Figure 5-6) – strong/weak impact of network externality versus strong/weak degree of customer lock-in. Particularly, the "network externality – customer lock-in (NE-CL)" framework presents long-term success potential of e-business models because it generally takes longer for e-business new ventures to develop the impact of network externality and customer lock-in. Furthermore, the NE-CL framework can also help develop competitive strategies of each e-business model in the CSI.

5.3.2.2 Evaluation of e-Businesses in the Container Shipping Industry with the NE-CL Framework

Figure 5-5 shows that each e-business model in the container shipping industry has different impacts of network externality. In the short term, marketplace-like e-business models, such as e-marketplaces, e-PSPs, and e-CSPs, have stronger network externality than others because the more buyers in the e-marketplaces, the more sellers will join the e-marketplaces expecting additional business potentials, and vice versa. In other words, adding new users will provide more 'direct' value to the current users of the e-marketplace. It will simply follow Metcalf's Law that the value of network is proportional to the second order of the number of users. However, in the long run, the network externality of the marketplace-like e-business models will be saturated over time because marginal benefits from the additional users will be offset by the increasing costs of finding the right trading partners.

Meanwhile, benefits from the network externality of the CTPs are weak when the number of users is few in the early stage of business development since adding a new user does not necessarily mean that the current users could directly reduce their logistics management costs. In order to receive benefits from new users, both new users and current users must actually do the collaborative business, which is not easy to develop in such a short period of time. Put another way, immediate and direct impacts from the new users on the benefits of current users will be limited in the short run. However, in the long term, the CTPs have much stronger network externality, which can exceed the network externality of e-marketplace. Since, for example, exchanging transportation-related documents through CTP's web-based service is very sticky due to high switching costs, the customers of the CTP service can substantially reduce communication and administrative costs once it reaches a critical mass of users.

On the other hand, the portals will provide very little network externality to the users. They just show market information with few connections among the users. So the number of users of the portals does not change the overall value of the network.

Besides the differences of the impact of network externality, one e-business model's degree of lock-in to the service also differs from other e-business models' degree of lock-in (Figure 5-6). In principle, users of the CTP's service tend to be loyal to the service because the software of the CTPs has its own standards that allow the users to distribute transportation-related documents easily. Therefore, the CTP users are more likely to be locked in to the service. In contrast, the users of marketplace-like e-business models can change their service choices more freely from one place to another because those e-business models require fewer standards than the CTP service. Furthermore, the portal users are much less locked in than the CTP users since the portal service has low network externality and the fewest standards among the e-business models in the CSI.

In summary, this analysis with the "NE-CL" framework maintains that the portal model is relatively less valuable to the users than other e-business models in the CSI. On the contrary, the CTPs can provide long-term value to their users through positive network externality and higher degree of customer lock-in. Therefore, the portals have the lowest long-term success potential and the CTPs have the highest long-term success potential among the e-business models in the CSI.

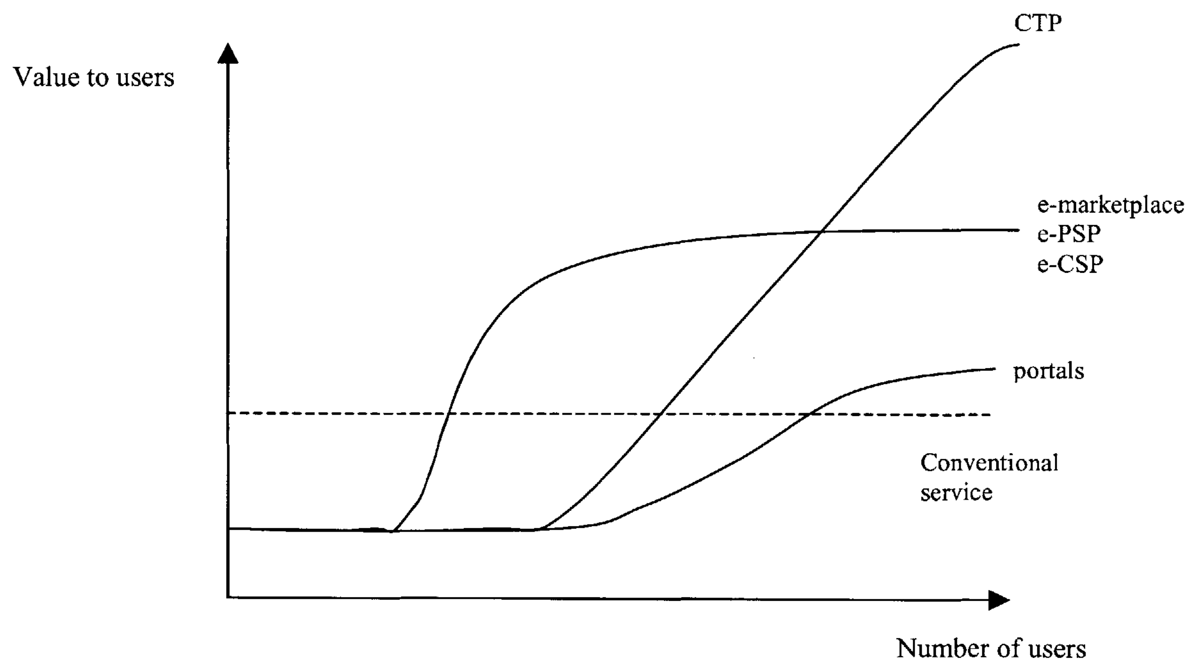


Figure 5-5 Impacts of Network Externality for e-Business Models in the Container Shipping Industry

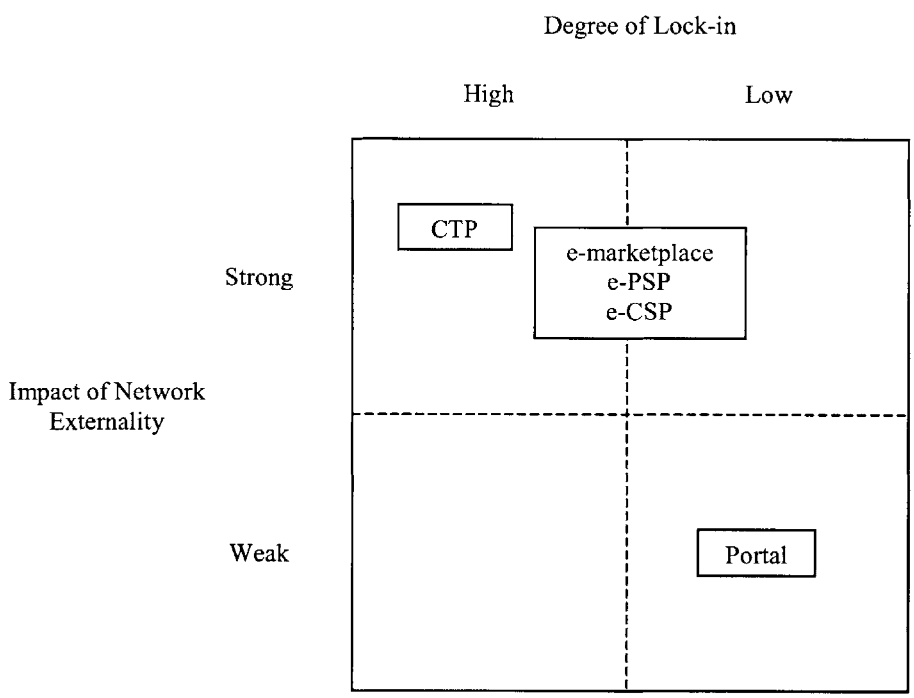


Figure 5-6 Evaluation of e-Business Models in the Container Shipping Industry with the NE-CL Framework

5.3.2.3 Development of Competitive Strategies from the Analysis with the NE-CL Framework

The analysis with the NE-CL framework shows that e-business models in the CSI have different impacts of network externality and degrees of customer lock-in. For example, the CTPs have strong network externality with higher level of customer lock-in, taking a longer time to reach critical mass for network externality benefits. The marketplace-like e-business models, such as e-marketplace, e-PSP, and e-CSP, have strong network externality with medium level of customer lock-in, taking a relatively short time to achieve network externality benefits. Meanwhile, the portals have weak network externality with a low level of customer lock-in. These different characteristics in the NE-CL framework can help each business model develop different competitive strategies.

First of all, the CTPs will compete with three strategic foci: the product-oriented approach, being niche players, and developing good relationships with incumbent players. First, because the CTPs are developing sophisticated software that provides efficiency to current transportation management functions of carriers and shippers, their competitive advantage should originally come from their own products so that they tend to adopt a product-oriented approach for competition. Once the product is good enough to win over competitors, it will attract more users, eventually providing positive network externality. Second, the CTPs will focus on a particular set of customers or a particular set of transportation management functions for their products/services in order to develop a critical mass of users who might be loyal to the CTPs' service. In other words, although benefits from the network externality for the CTPs' services are tremendous in the end, the CTPs should survive through the slow adoption rate in the early stage. Therefore, the CTPs had better be niche players and start to develop a critical mass of users of the specific functions of transportation management at first. For example, FreightDesk.com, which provides transportation management software, is targeting freight forwarders that are most desperate for automated transportation management service, thereby attracting loyal users as soon as possible to survive through early difficulties. Third, since the CTPs try to upgrade current manual-based transportation or trade management processes by providing internet-based software, collaboration with incumbent industry players is very important. Therefore, they try to maintain good relationships with the incumbents, especially large and powerful ones. For example, Vastera, which offers trade management service, maintains a close relationship with Ford to provide auto-related logistics management service.

Unlike the CTPs, marketplace-like e-business models, such as e-marketplaces, e-PSPs, and e-CSPs, should develop different competitive strategies. Since the impact of network externality on marketplace-like e-business models is quicker than that of the CTPs, the marketplace-like e-business models focus more on promotion and marketing to push early adoption by customers. In other words, they try to enjoy first-mover advantage by attracting buyers and sellers as quickly as possible. Once an e-marketplace reaches a critical mass of users, it can enjoy the benefit of network externality and dominate the business against competitors. Therefore, the marketplace-like e-business models have spent more money on advertising, promotion, press relationships, and so forth than other e-business models. However, a weakness of this strategy is that an e-marketplace will be more likely to fail if it does not spend enough money on marketing to persuade potential customers to join the e-marketplace. It may be a risky 'all-or-nothing' competitive strategy.

Meanwhile, because the portals have few benefits from network externality or from customer lock-in, they might have difficulty in finding suitable competitive strategies. In fact, they are more vulnerable to competition because they have few revenue sources and a low level of customer lock-in. The only implementable strategy for the portals might be to collaborate with other e-business models because resourceful market information provided by the former can help the latter attract more users. The portals themselves seem unlikely to be profitable business in the long run.

In summary, different degrees of network externality and customer lock-in drive different strategic choices to the e-business models in the container shipping industry. Each player should adopt the strategies that provide maximum benefits from the perspective of different degrees and time frames of network externality. Therefore, the CTPs should follow the strategies of the product-oriented approach, of being a niche approach, or of developing good relationships with incumbent players, whereas e-marketplaces would take aggressive promotion and marketing strategies. However, because the portals have weak network externality and a low degree of customer lock-in, they should collaborate with other e-business models in order to survive.

5.3.3 Evaluation Using the "Market Type – Customer Focus" (MT-CF) Framework

5.3.3.1 "Market Type – Customer Focus" (MT-CF) Framework

The third criterion for evaluating e-business models, MT-CL framework, is to analyze the customer focus of e-business models with market types in which e-business models are competing. In other words, e-business models are more likely to succeed if their customer focus matches with a market player who has relatively stronger buying power than other market players. This framework is based on the assumption that, given the difficulty of diffusing new technology into the traditional relationship-based industries such as the container shipping industry, technology-oriented new ventures utilizing stronger buying power of potential customers are more likely to succeed.

There are two market types in MT-CF framework: the buyers' market and the sellers' market. The buyers' market is the marketplace where buyers have stronger buying power than sellers. For example, the ship supplier market in the container shipping industry, where carriers buy ship management-related products from ship suppliers, is a buyers' market because carriers, or buyers, have much stronger bargaining power than the suppliers. In contrast, the sellers' market is the marketplace where sellers have stronger bargaining power than buyers. For example, a spot market of container shipping service, where carriers sell container shipping capacity to shippers on a short-term basis, is a sellers' market since carriers, or sellers, have stronger bargaining power than shippers, who are generally small companies in the spot market.

Two variables are important in determining the market type: relative market concentration and relative service dependency. First, the market concentration means the extent that a market is controlled by a certain number of players. In other words, the fewer players controlling the market, the higher the market concentration. To determine the market type, relative market concentration can be used: the ratio of buyers concentration and sellers concentration (i.e., relative market concentration = buyers concentration / sellers concentration). If the relative market concentration is higher than one, the market tends to be a buyers' market because buyers might utilize their concentrated buying powers. Similarly, if the relative market concentration is lower than one, the market is more likely to be a sellers' market. The second variable, service dependency, is defined as how urgently a market player is dependent upon the service. In order to estimate the market type, relative service dependency (i.e., the ratio of buyers' service dependency and sellers' service dependency), can be used. Thus, if the relative service dependency is larger than one, the market tends to be a sellers' market since sellers can be in a better bargaining position by exploiting the buyers' service dependency. Likewise, if the relative service dependency is smaller than one, the market is more likely to be a buyers' market.

The MT-CF framework in Figure 5-7 provides two places of success and failure respectively. An e-business model tends to succeed if the market type, buyers' or sellers' market, coincides with the customer focus of the e-business model. On the contrary, if the market type and customer focus of e-business model are different, the e-business model is more likely to fail.

This framework is particularly useful when e-business models have clear sets of buyers and sellers so that the market type and customer focus are easily identified. For example, marketplace-like e-business models, such as e-marketplace, e-PSP, and e-CSP, can be effectively analyzed with the MT-CF framework.

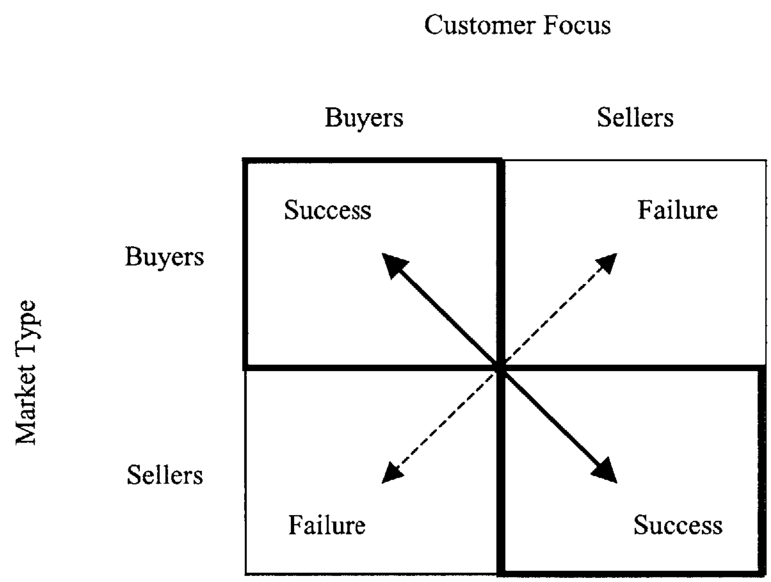


Figure 5-7 - The "Market Type – Customer Focus" (MT-CF) Framework

5.3.3.2 Evaluation of e-Business Models in the Container Shipping Industry with the MT-CF Framework

Table 5-3 and Figure 5-8 show the evaluation of e-business models in the container shipping industry with the MT-CF framework. The CTPs and e-PSPs are well positioned to be potentially successful. They are competing in a buyers' market, focusing on buyers as targeted customers. They have the right match of market type and customer focus. Thus, they are more likely to succeed than other e-business models in the CSI.

On the contrary, e-marketplaces clearly choose the wrong customer focus to be sustainable. The e-marketplaces, which provide internet-based marketplace for the spot market of container shipping service, are offering their service in a sellers' market while they target buyers. So, the e-marketplaces might be difficult to succeed given this wrong combination of market type and customer focus. They should change their customer focus from buyers to sellers in order to be successful.

Meanwhile, the portals and e-CSPs are in a gray area where they are competing in a neutral market type. Their potential success might depend on how they creatively partner with buyers or sellers to be more powerful in the marketplaces.

Table 5-3 Application of "Market Type – Customer Focus" Framework to e-Business Models in the Container Shipping Industry

	Portal	e-Marketplace	CTP	e-PSP	e-CSP
Buyers	C(1), S(2), I(3)	Shippers, 3PLs	C, S, I	Carriers	Carriers, Brokers
Sellers	Tech. company	Carriers	Tech. company	Ship suppliers	Charterers
Higher Buyers or Sellers Concentration	Buyers	Sellers	Buyers	Buyers	Neutral
Lower Buyers/Sellers Service Dependency	Buyers	Neutral	Buyers	Neutral	Neutral
Market Type	Buyers	Sellers	Buyers	Buyers	Neutral
Customer Focus	Neutral	Buyers	Buyers	Neutral	Neutral
Success Potential	Low-Medium	Low	Medium-High	Medium-High	Low-Medium

(1) C: Carriers, (2) S: Shippers, (3) I: Intermediaries

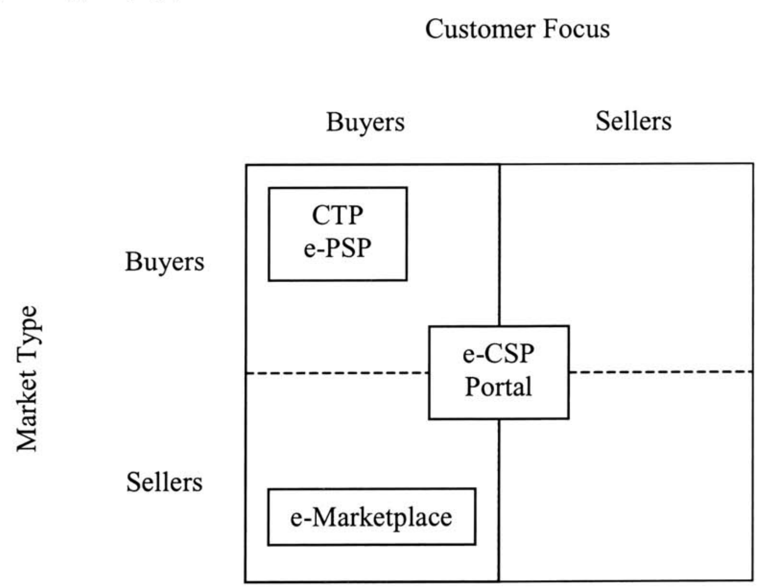


Figure 5-8 Evaluation of e-Business Models in the Container Shipping Industry with the MT-CF Framework

5.3.4 Summary

In this section, current e-business models in the CSI have been analyzed with three different frameworks – A-CA framework, NE-CL framework, and MT-CF framework. The analysis explained the reasons why many e-business models in the CSI have failed, found out the potentially successful e-business models, and recommended the desirable competitive strategies of e-business models in the CSI. Among the major findings are:

- The CTPs will be most likely to succeed in the long term as well as in the short term.
- The CTPs and carrier-oriented portals are likely to develop strategic alliances together and their alliances might be successful.
- Besides the CTPs, e-PSPs are also likely to succeed due to their right match of market type and customer focus.

Therefore, this comparative evaluation of e-business models in the CSI draws the conclusion that the most promising e-business models in the CSI are 1) the CTPs in alliance with carrier-oriented portal and 2) e-PSPs for ship supplies procurement. These promising e-business models will be more likely to impact the container shipping industry in the long term.

5.4 Conclusions

This chapter has attempted to analyze internet-based business (e-business) models in the container shipping industry. Five different e-business models – portal, e-marketplace, collaborative tool provider (CTP), e-procurement service provider (e-PSP), and e-chartering service provider (e-CSP) – have been launched in the container shipping industry with unique competitive strategies and technology settings. Case studies of each e-business model show that the boundary of e-business models becomes blurry over time, resulting in active consolidation among the e-business companies in the CSI, and an e-business model, which is more friendly to major industry players and traditional business relationships in the CSI, such as CTP, is more likely to succeed in the long run. Furthermore, a comparative analysis of e-business models in the CSI using the three frameworks – A-CA framework, NE-CL framework, and MT-CF framework – developed from a technology strategy perspective confirms that two e-business models – CTPs in alliance with carrier-oriented portals and e-PSPs – are more likely to succeed in the long run.

The outcome of this research can be used for assessing the potential impacts of e-business on the container shipping industry: Since it is now understood that two promising e-business models might be more successful than others, it is possible to measure the impacts, qualitatively or quantitatively as appropriate, of e-business activities on the container shipping industry. For example, an analysis of the potential interactions between strategic challenges of carriers and two promising e-business models can provide a general picture as to how the container shipping industry will be impacted by e-business activities and how carriers should respond to those impacts.

In the following chapters, a system dynamics modeling methodology is applied in order to measure the impacts of e-business activities on the container shipping industry.

Chapter 6 A Generic Model for the Dynamics of Supply-and-Demand in the Container Shipping Industry

6.1 Introduction

To analyze the impacts of e-business on the container shipping industry, the traditional dynamics of supply-and-demand in the container shipping industry should be investigated and used as a reference system. This chapter explains a system dynamics model for the dynamics of supply-and-demand in the container shipping industry. Although there have been several system dynamics models dealing with general dynamics of supply-and-demand in different industries (Hernandez, 1990; Sterman, 2000; Taylor, 1999; Thornton, 1992; Weil, 1998), the model developed in this research is the first attempt to simulate the dynamics of supply-and-demand in the container shipping industry.

A brief description of the historical development of supply-and-demand dynamics is first presented. Section 6.3 provides the overview of the causal relationships that drive the dynamics of supply-and-demand. Section 6.4 explains a system dynamics model for the dynamics of supply-and-demand in the container shipping industry, including the scope and boundary of the model and quantitative formulations that compose the causal linkages. Section 6.5 validates the model by calibrating it with real industry data. The chapter concludes with the findings from the modeling of dynamics of supply-and-demand in the container shipping industry.

6.2 Historical Developments of Supply-and-Demand in the Container Shipping Industry

The dynamics of supply-and-demand are in general composed of three groups of variables: supply, demand, and profitability. A closer look at these variables helps one understand the internal dynamics of supply-and-demand; i.e., how the balance between supply and demand of service could determine the price of service and the profitability of the service provider. Hence, this section explores the historical developments of the variables of supply-and-demand in the container shipping industry. Although it is desirable to analyze the variables for a longer period of time, the analysis focuses on the data in the 1990s due to the lack of data availability.

6.2.1 Demand for Container Shipping Service

The demand for container shipping service has increased dramatically since the first container shipping service in 1956. Figure 6-1 reveals that the number of containers transported, measured by million TEUs of port handling, has substantially increased over time. On average, the demand for container shipping service has grown at 10.3% per year from 1975 to 2000. Although the demand has increased constantly, the growth rates have been changing with a decreasing trend over time. Another demand metric is annualized container shipping demand in the 1990s, showing that demand increased from 10.4 million TEUs per year in 1990 to 17.9 million TEUs per year in 1999, which is a growth rate of 8% per annum (Figure 6-2). This figure also confirms that the growth rates of the demand have changed over time. In summary, the demand for container shipping service has been increasing with different growth rates over time.

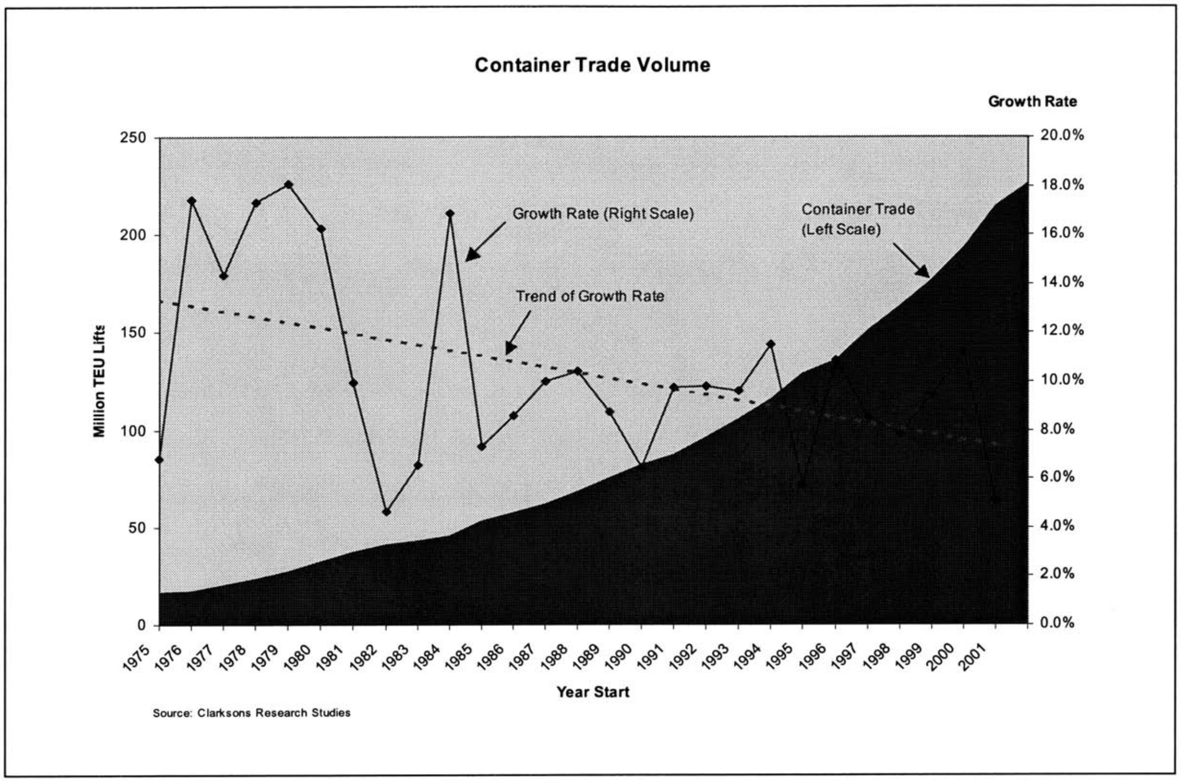


Figure 6-1 Number of Containers Handled at Ports per Year

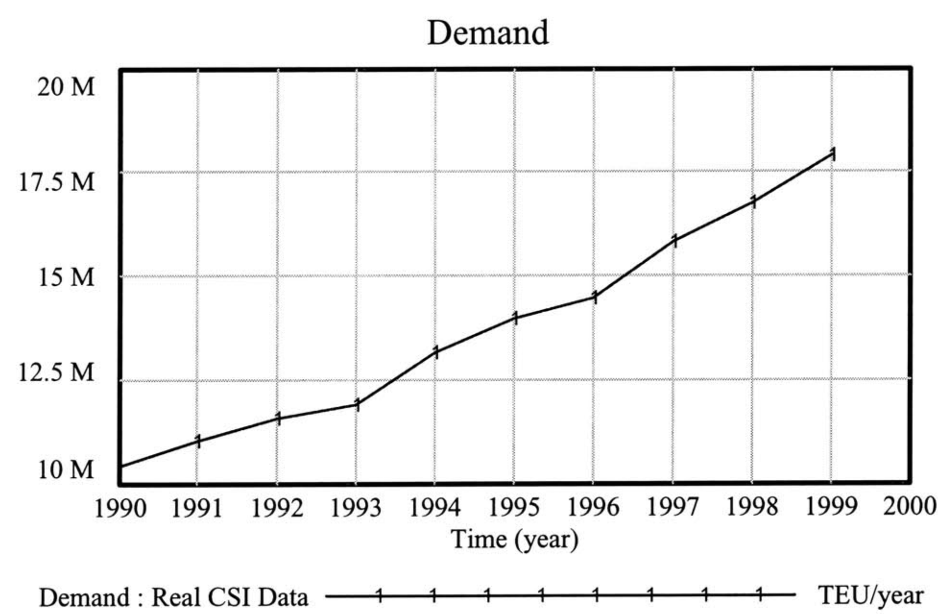


Figure 6-2 Annualized Container Shipping Demand in the 1990s

(Source: Drewry Shipping Consultants, 1999)

6.2.2 Supply of Container Shipping Service

There are five variables for the supply for container shipping service: containership capacity, containership capacity on order, order rate of containership capacity, delivery rate of containership capacity, and discard rate (or scrapping rate) of containership capacity.

As illustrated in Figure 6-3, the containership capacity has increased relentlessly for the past 20 years. The containership capacity at the end of 2000 amounted to 4.8 million TEUs, which is around nine times more containership capacity than that of 1981. The year-over-year growth rate for the past two decades ranges from 5.0% to 18.6% and the average growth rate is around 10.4% per annum. Like the demand for container shipping service, the growth rates of containership capacity have been changing over time although the containership capacity has been ever increasing.

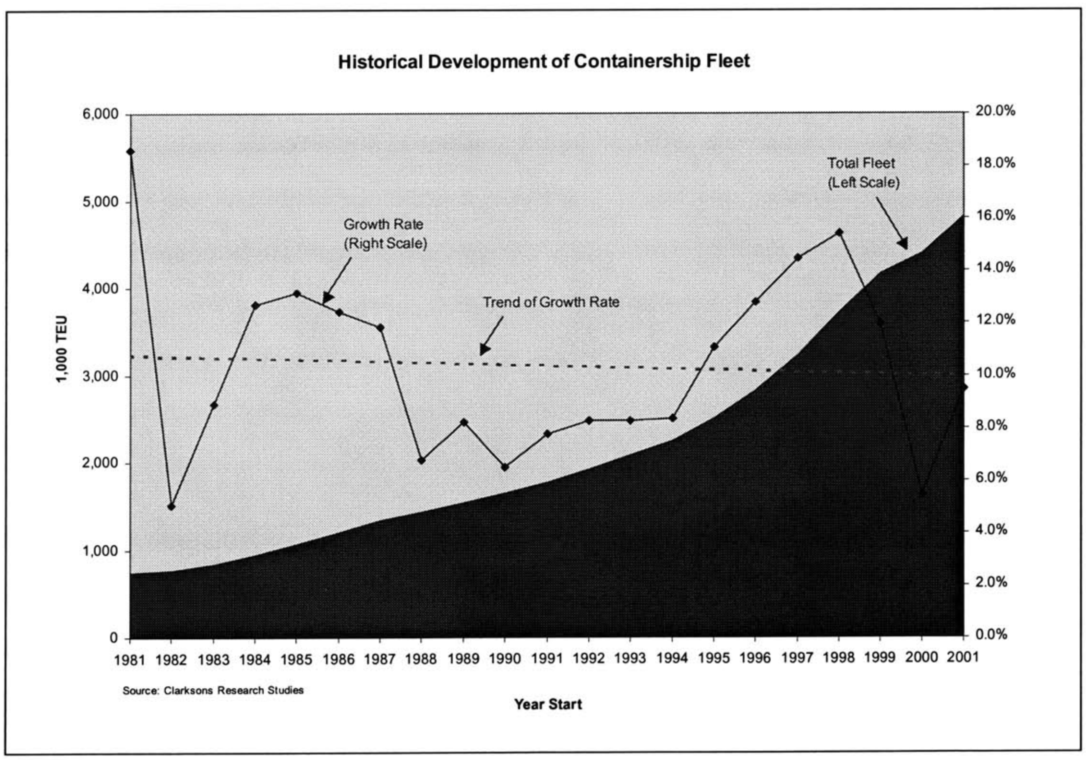


Figure 6-3 Containership Capacity over Time

A closer look at the containership capacity data in the 1990s also confirms that the containership capacity has been increasing over time (Figure 6-4). Particularly, containership capacity has increased faster from 1995 to 1999.

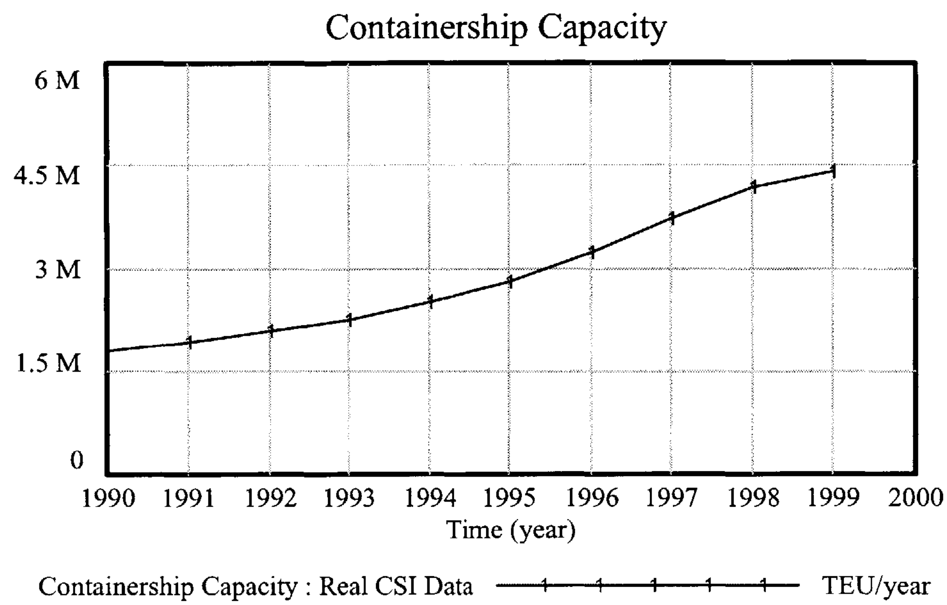


Figure 6-4 Containership Capacity in the 1990s

(Source: Clarksons Research Studies)

Meanwhile, the containership capacity on order, which is the containership capacity being constructed in shipyards, has increased over time with some cyclical behaviors (Figure 6-5). In addition, both the order rate, which is the containership capacity ordered by carriers per year, and the delivery rate, which is the containership capacity delivered by shipyards to carriers per year, show similar developments over time (Figure 6-6, Figure 6-7).

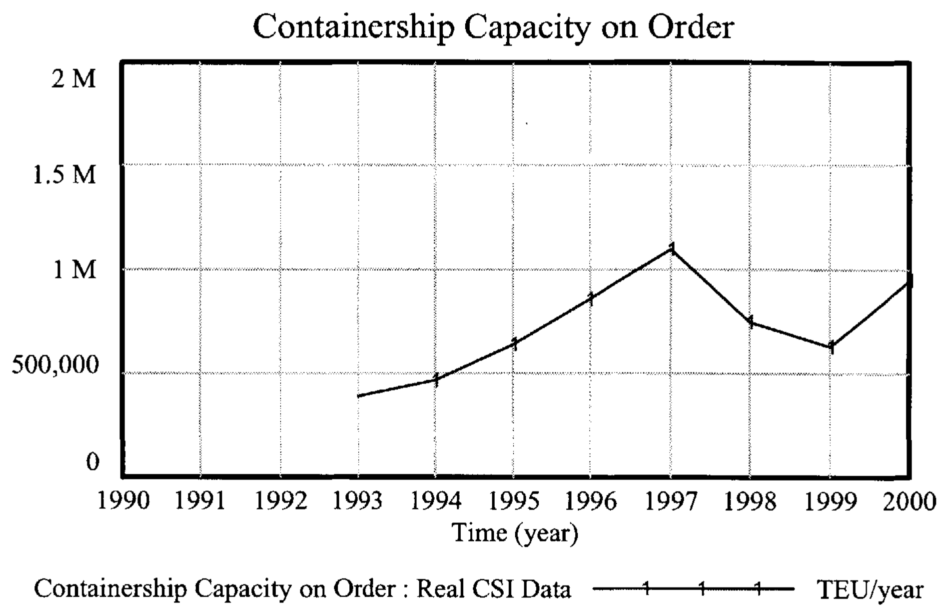


Figure 6-5 Containership Capacity on Order in the 1990s

(Source: Clarksons Research Studies)

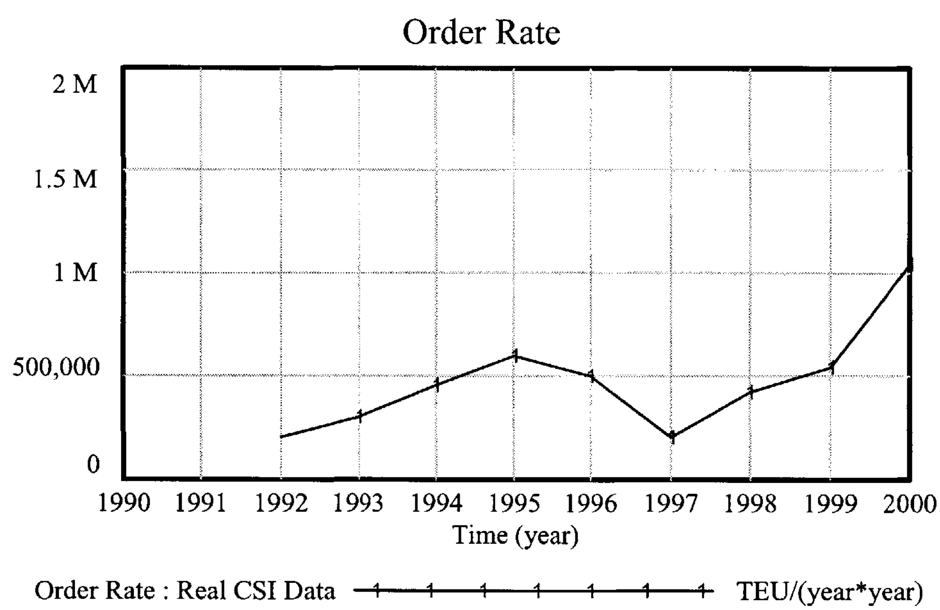


Figure 6-6 Order Rate of Containership Capacity in the 1990s

(Source: Clarksons Research Studies)

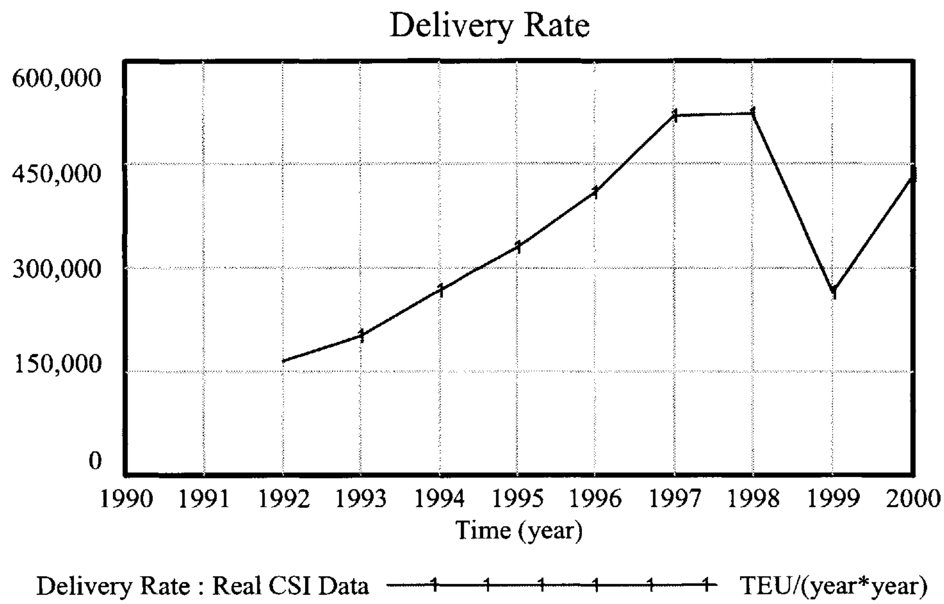


Figure 6-7 Delivery Rate of Containership Capacity in the 1990s
(Source: Clarksons Research Studies)

On the contrary, the discard rate, which is the containership capacity scrapped per year, has been relatively minimal compared with the total containership capacity (Figure 6-8). For example, the amount of capacity scrapped in 1998 when it was the highest is only 2% of containership capacity in 1998. The reason for this is that because containerships can be used around 25 – 30 years, the early containerships built in the early 1960s started to be scrapped in the early 1990s. Therefore, the discard rate will increase as more containerships reach their maximum usage of life.

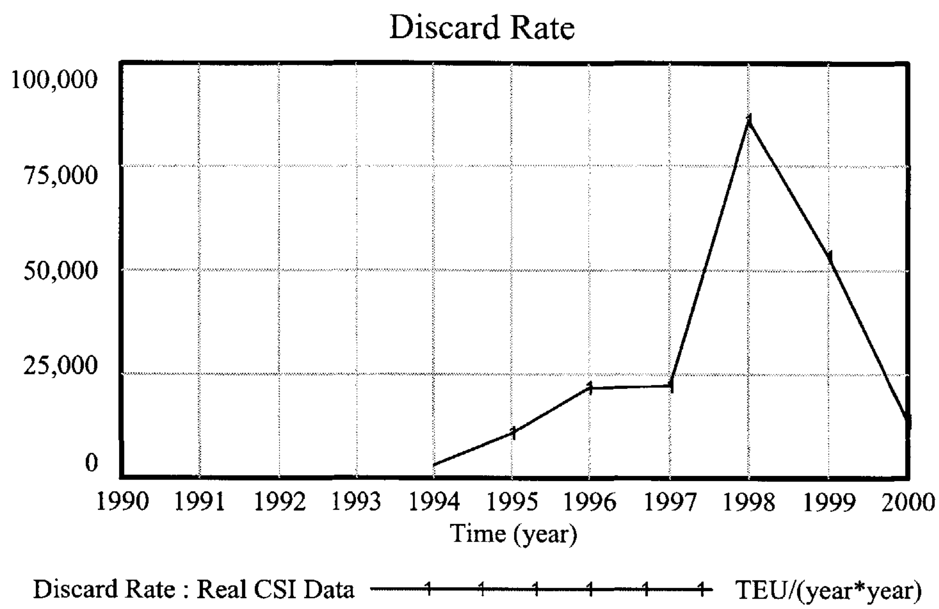


Figure 6-8 Discard Rate of Containership Capacity in the 1990s
(Source: Clarksons Research Studies)

6.2.3 Profitability of Container Shipping Service

The profitability[44] of container shipping service is determined by the revenue from container shipping service and the cost associated with it. The revenue comes from the freight rate of container shipping service, which is mainly determined by the utilization, and the utilization is calculated by demand divided by the annualized containership capacity available. Meanwhile, the cost of container shipping service is generally determined by external factors, such as the impact of economy of scale, fuel price, etc.

Unlike the demand and containership capacity of container shipping service, the utilization and freight rate of container shipping service in the 1990s have been decreasing over time even though there are some local ups and downs (Figure 6-9, Figure 6-10). The major reason for this is that the growth rates of containership capacity have always

[44] The profitability can be defined in several ways; in this research, however, gross profitability, which is operating margin (i.e., revenue minus cost) divided by revenue, is used for the profitability data.

exceeded the growth rates of the demand of container shipping service, particularly in the late 1990s.

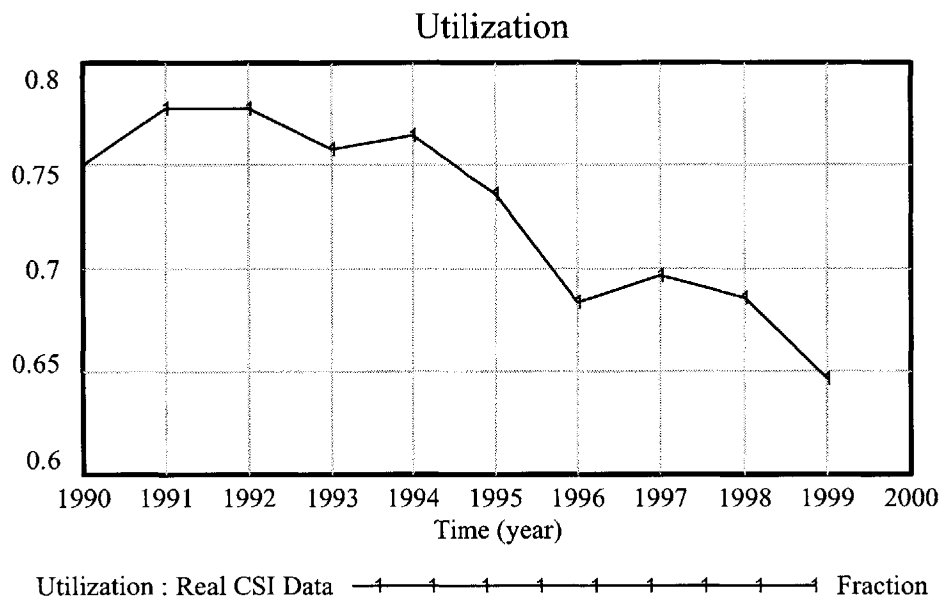


Figure 6-9 Utilization of Container Shipping Capacity in the 1990s
(Source: Drewry Shipping Consultants, 1999)

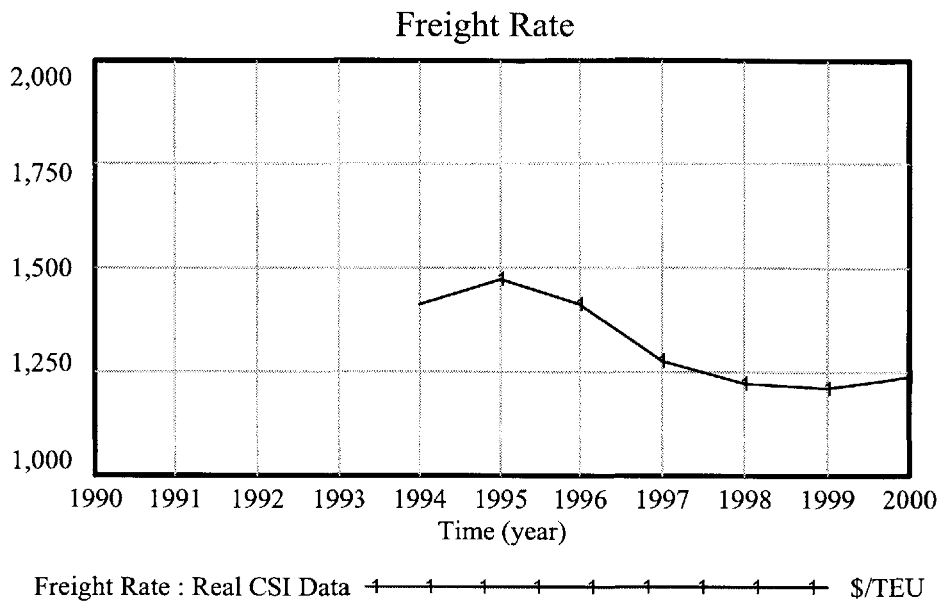


Figure 6-10 Freight Rate of Container Shipping Service in the 1990s
(Source: Containerization International)

While the utilization and freight rate data are readily available in the 1990s, the cost data are not easily obtainable. Although it might be possible to estimate the cost structure of individual carriers, estimating the industry-wide cost structures is very difficult. However, it is expected that the cost of container shipping service must have been decreasing substantially in order to be profitable under the environment of ever-eroding freight rates. Particularly, the impact of economies of scale, which attempts to reduce the unit cost by deploying larger containerships, has enabled carriers to manage to be profitable despite the decreasing freight rates.

Even though the cost data are not directly available, the profitability data could help estimate the cost data indirectly. There have been very little well-tracked industry-wide profitability data for the container shipping industry. Part of this reason is that many carriers are privately held – only several large carriers are publicly held companies – so that they tend not to publish their detailed financial performances. The only available data on industry profitability are given by the *American Shipper*, which has reported container carriers' annual average profitability from 1996. Given this difficulty, the author collected profitability data of six major publicly held container carriers[45] in the 1990s, calculated the average profitability of those carriers, and finally estimated the industry profitability data in those periods by regression analysis using the *American Shippers* data. Figure 6-11 presents the estimated average profitability of all carriers in the container shipping industry and that of six major container carriers in the 1990s. The profitability of container carriers in the 1990s changes cyclically ranging from 4.5% to 7.1%. The average profitability in the 1990s is around 6.42%.

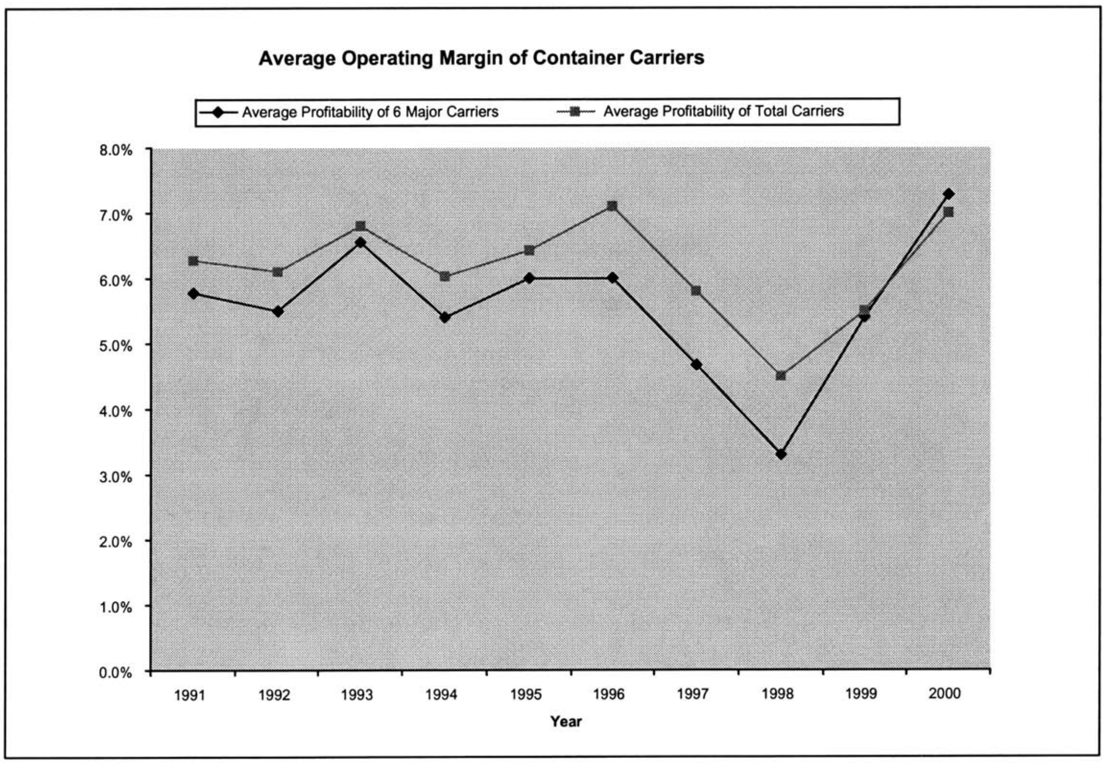


Figure 6-11 Profitability of Carriers in the 1990s

(Source: American Shippers; Financial reports from carriers)

[45] The six carriers are Evergreen, Hanjin, K-Line, Mistui OSK, NOL/APL, and NYK.

6.3 Causal Relationships of Supply-and-Demand in the Container Shipping Industry

In system dynamics modeling, it is assumed that the historical developments of interrelated variables can be explained by the internal causal relationships among them. In other words, the causal linkages among the variables comprising the system should control the dynamic changes of the variables over time. Developing a system dynamics model requires, therefore, one to identify and quantify the internal causal linkages among the variables and regenerate the dynamic behaviors of the variables.

Since the causal linkages among the variables are complex, interrelated, and hard to explain in words, the causal loop diagrams (CLD) are commonly used for identifying and illustrating the causal relationships. For example, Figure 6-12 shows the causal loop diagrams for the dynamics of supply-and-demand of the container shipping service. The causal loop diagrams in the system dynamics modeling is a graphical methodology of showing the causal linkages with arrows connecting the variables. The polarity of a connecting arrow is determined by the direction of causal linkage between the connected variables. For example, if the two connected variables change in the same directions – i.e., the increase of one variable causes the increase of the other variable, or the decrease of one variable causes the decrease of the other variable – the connecting arrow should have a positive sign. If the two connected variables change in the opposite directions – i.e., the increase of one variable causes the decrease of the other variable, and vice versa – the connecting arrow should have a negative sign.

Meanwhile, a loop composed of the chain of circulating variables can be classified into either a balancing loop or a reinforcing loop. For instance, a loop is called a balancing loop if one variable in the loop starts in an increasing trend and ends in a decreasing trend after passing through all causal linkages along the loop, and vice versa. The balancing loop prevents the variables from increasing or decreasing continuously and makes them change cyclically. However, a loop is called a reinforcing loop if one variable in the loop starts in an increasing trend and ends in an increasing trend again after passing through all causal linkages along the loop, and vice versa. The reinforcing loop always makes the variables change in one direction, either increasing or decreasing.

In general, the causal relationships of an industry that has a high fixed cost structure and supplies commodity-like products or services are well known (Auh, et al. 2001; Sterman, 2000; Weil 1998). Since the container shipping industry has similar characteristics, the causal linkages among the industry variables could be extended from the previous research with some modifications reflecting the industry-specific characteristics.

From a broader perspective, three causal relationships are expected to govern the balance of supply-and-demand of the container shipping service – reinforcing "demand – capacity" feedback loop, balancing "freight rate – demand" feedback loop, and balancing "freight rate – capacity" feedback loop. Detailed illustrations of each feedback loop are provided in the following.

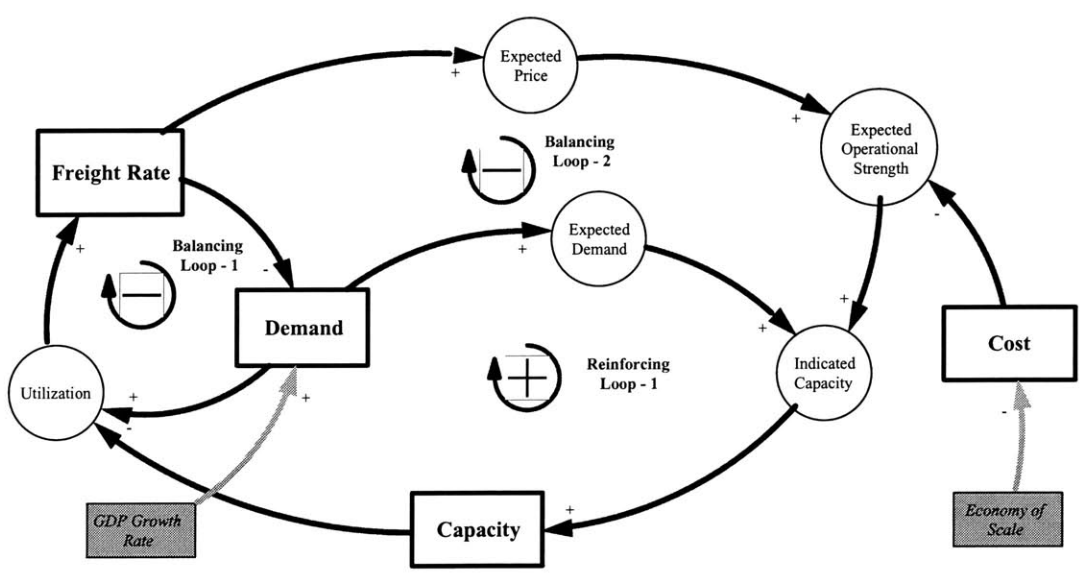


Figure 6-12 Causal Loops for Dynamics of Supply-and-Demand in the Container Shipping Industry

6.3.1 Reinforcing "Demand – Capacity" Feedback Loop

Historical data on demand and capacity of the container shipping service show that they have increased constantly over time while freight rate has decreased. A reinforcing loop might be involved in this dynamics (see Figure 6-13). As freight rate decreases, demand of the container shipping service will pick up given that the external impact of the GDP growth rate holds constant. The increased demand will force carriers to invest in more container ships to meet the demand of container shipping service. Then, the increased capacity will lower the utilization, which is the demand divided by capacity, and the lowered utilization further reduces the freight rate. Therefore, these dynamics construct a reinforcing loop and explain the ever increasing demand and supply, and decreasing freight rate.

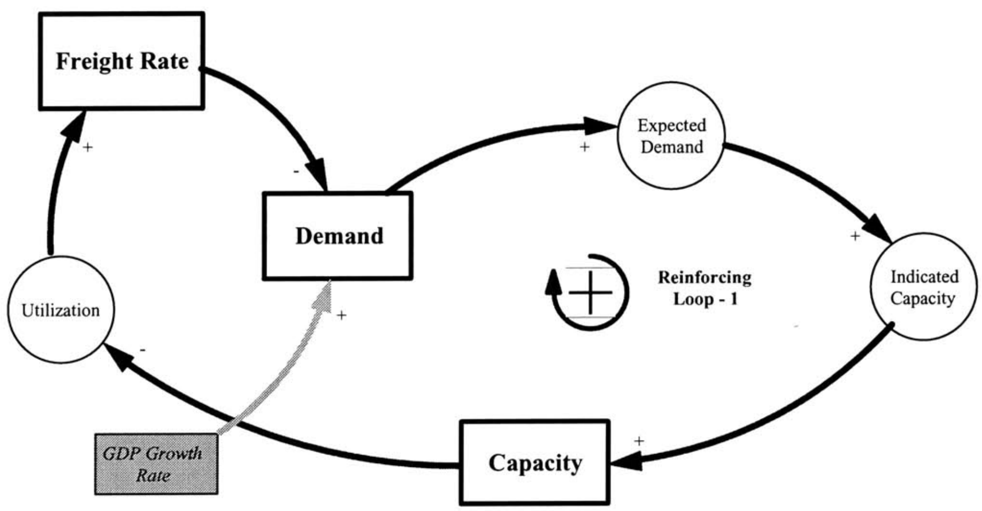


Figure 6-13 Reinforcing "Demand-Capacity" Feedback Loop

6.3.2 Balancing "Freight Rate – Demand" Feedback Loop

Although demand of the container shipping service has been constantly increasing over time, the growth rate of the demand is not constant; indeed, the growth rate of the demand has varied over time. A balancing loop might have controlled the changing growth rate of the demand (see Figure 6-14). As freight rate decreases, demand will increase because the cheaper freight rate could draw more demand for the container shipping service. The increased demand will then increase the utilization, and the increased utilization will increase the freight rate, thereby constituting a balancing feedback loop.

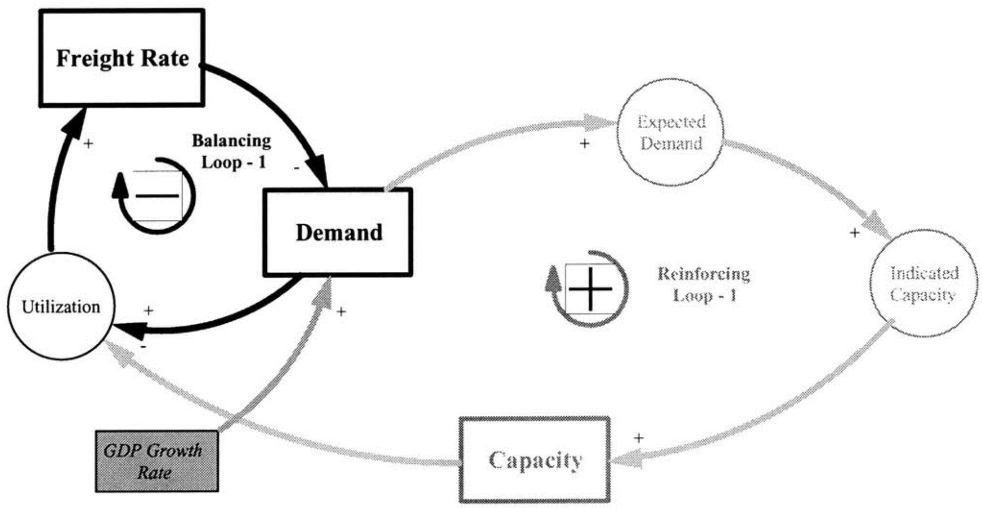


Figure 6-14 Balancing "Freight Rate - Demand" Feedback Loop

6.3.3 Balancing "Freight Rate – Capacity" Feedback Loop

The capacity of container shipping service measured in TEUs available per year has been increasing with changing growth rates. Another balancing feedback loop could explain this changing growth rate of capacity (see Figure 6-15). As freight rates decrease, the expectation of carriers of the future freight rate will decrease and so does the financial strength to invest in more containership capacity. Then the decreased financial strength of carriers will make carriers reduce their containership capacity; however, the reduced capacity will increase the utilization so that the freight rate will increase. Therefore, these dynamics provide another balancing feedback loop.

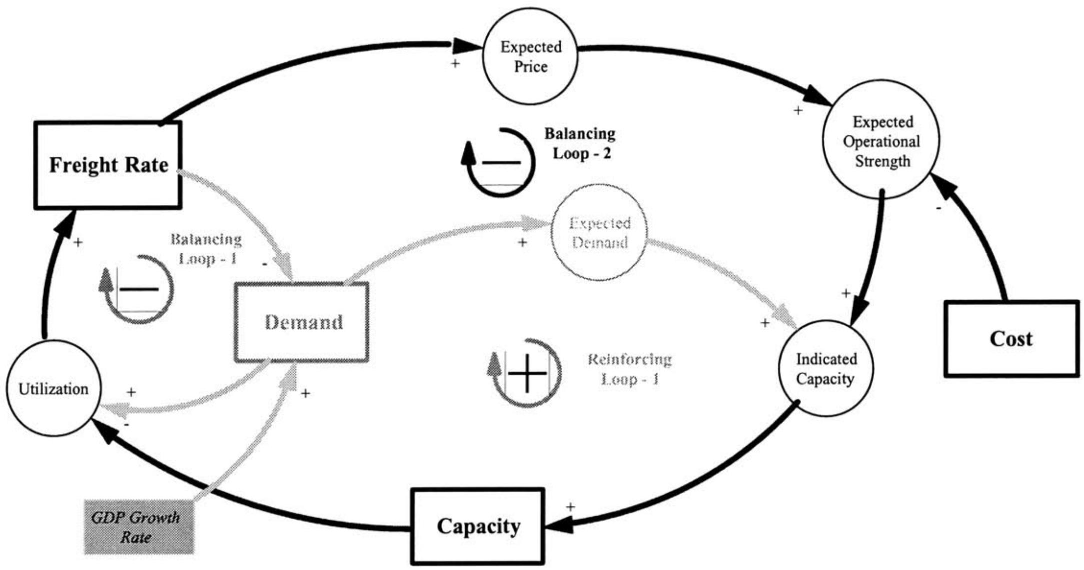


Figure 6-15 Balancing "Freight Rate - Capacity" Feedback Loop

6.4 Model Structure

This section contains a formal description of a system dynamics model for the dynamics of supply-and-demand in the container shipping industry. The model is developed based on a system dynamics model for the airline industry (Weil, 1998); however, several updates of the model structures are undertaken to reflect the characteristics of the container shipping industry, and efforts are made to quantify the causal relationships and estimate the parameters.

6.4.1 Purpose and Boundary of the Model

The purpose of the model for the dynamics of supply-and-demand in the container shipping industry is to understand the internal dynamics of determining the supply and demand of container shipping service and the profitability of carriers, and to simulate the historical trends of industry behaviors in the 1990s. The model will then be used as a reference system to test the impacts of e-business on the container shipping industry.

The model purpose defines the scope and focus of the model that are reflected in the model boundary. Table 6-1 delineates the primary features included in the model (endogenous variables), the exogenous parameters, and what is excluded from the model.

Among the features ignored in the model is the capacity of shipyards. It is possible that, if the orderbook of shipyards becomes closer to the maximum of shipyards' shipbuilding capacity and delivery of ships is expected to be delayed, carriers would tend to order ships in advance in order to receive the newly built ships on schedule. These activities could increase the order rate, containership capacity on order, and containership capacity, etc., more than in the normal environments. However, because the impact of shipyard capacity on the change of containership capacity is in general limited for a short period of time, ignoring this impact does not change the general trends of supply-and-demand dynamics in the container shipping industry. Therefore, the shipyard capacity is assumed to be unlimited in the model.

Table 6-1 Model Boundary Chart for the Model of Dynamics of Supply-and-Demand in the Container Shipping Industry

Endogenous Variables	Exogenous Parameters	Excluded in the model
• Indicated demand * • Indicated demand growth rate • Indicated demand growth rate by GDP growth rate • Indicated demand growth rate by freight change • Perceived GDP growth rate • Perceived freight rate change • Effect of demand change trend on unit administration cost • Freight rate • Effect of relative utilization on freight rate • Effect of utilization change trend on freight rate • Utilization • Demand • Net slot capacity • Containership capacity • Containership capacity on order • Order rate • Delivery rate • Discard rate • Desired containership capacity • Desired order rate from containership capacity • Desired order rate from fleet aging • Desired containership capacity on order • Profitability • Expected profitability • Effect of relative profitability on order	• GDP growth rate • GDP growth rate perception delay • GDP sensitivity on indicated demand • Freight rate perception delay • Freight rate sensitivity on indicated demand • Initial indicated demand • Demand adjustment delay • Average time interval for trend estimation • Initial freight rate • Time to adjust freight rate • Average time interval for trend estimation of utilization change • Utilization perception delay • Utilization trend sensitivity on indicated freight rate • Voyage TAB • Time to perceive utilization • Reference utilization • Planning horizon • Average time to project demand • Average voyages per year • Capacity adjustment time • Time to adjust capacity on order • Target profitability • Time to perceive profitability • Containership delivery time • Containership retirement age • Initial capacity • Initial capacity on order • Initial unit administration cost • Initial unit fixed cost • Initial unit variable cost • Effect of economy of scale on cost	• Shipyard capacity • Technology-driven demand increase

(*) The underlined variables are state variables in the model

For the purpose of presentation, the model has been decomposed into four major sectors. Section 6.4.2 describes the demand sector. The demand sector represents how the demand of container shipping service is determined. The next section contains the formulation describing the dynamics of freight rate. It is assumed that the freight rate of container shipping service is determined by the level of utilization. And then, the capacity sector is explained in section 6.4.4. The capacity sector simulates how carriers decide the acquisition of containerships. Finally, the cost structure of container shipping service is modeled in section 6.4.5.

6.4.2 Demand Sector

The demand sector models the development of container shipping demand. It is assumed that the demand for container shipping service is determined by two factors (Sterman, 2000; Weil, 1998): GDP growth rate and the change of freight rate. The GDP growth rate drives the overall increase of the container shipping demand whereas the change of freight rate explains the changing growth rate of the demand (see the causal loop diagram in Figure 6-14). Figure 6-16 shows the stock and flow structure for this sector.

The main input to this sector from other sectors is the freight rate, and the exogenous parameters to this sector include GDP growth rate, GDP growth rate perception delay, GDP sensitivity on indicated demand, average time interval for trend estimation, initial perceived price change, freight rate perception delay, freight rate sensitivity on indicated demand, demand adjustment delay, and initial perceived demand change. The output from this sector is the effect of demand change trend on administrative cost, which models the increasing administrative cost in order to serve the increasing amount of container shipping demand. The detailed equations are explained in the following.[46]

[46] For the purpose of presentation, the equations are expressed in functions used in Vensim DSS®, a system dynamics modeling software. The examples of the functions are SMOOTH, TREND, INTEG, etc. Detailed definition and characteristics of these functions can be found in http://www.vensim.com/documentation/vensim.htm and in Sterman (2000).

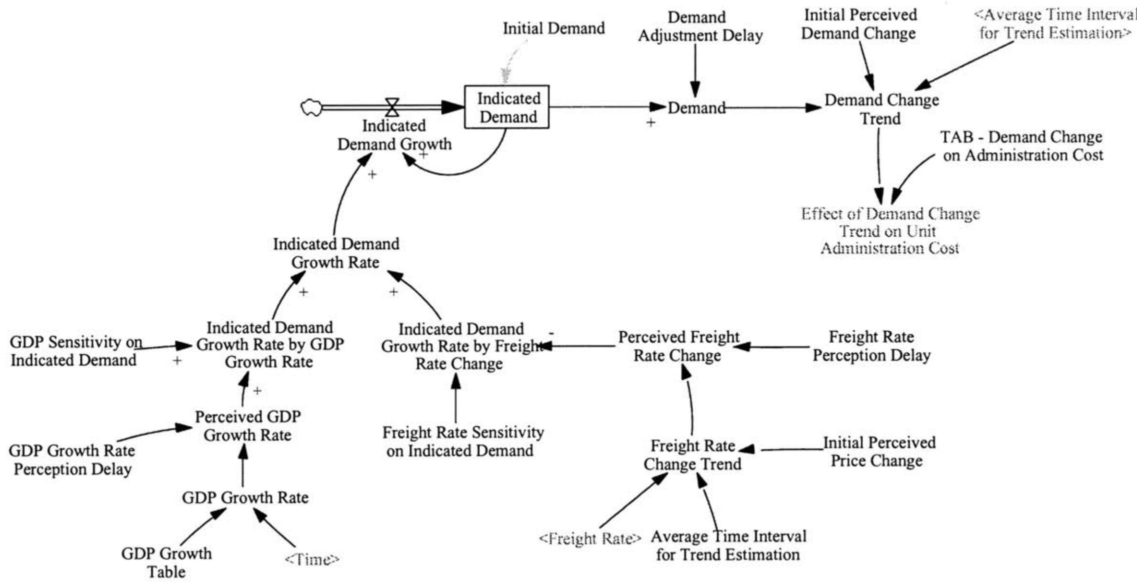


Figure 6-16 Structure of Demand Sector

(1) Demand Change Trend = TREND(Demand, Average Time Interval for Trend Estimation , Initial Perceived Demand Change)

(2) Demand = SMOOTH(Indicated Demand, Demand Adjustment Delay)

(3) Indicated Demand = INTEG (Indicated Demand Growth, Initial Demand)

(4) Indicated Demand Growth = Indicated Demand*Indicated Demand Growth Rate

(5) Indicated Demand Growth Rate = Indicated Demand Growth Rate by GDP Growth Rate + Indicated Demand Growth Rate by Freight Rate Change

(6) Indicated Demand Growth Rate by GDP Growth Rate = Perceived GDP Growth Rate*GDP Sensitivity on Indicated Demand

(7) Perceived GDP Growth Rate = SMOOTH (GDP Growth Rate, GDP Growth Rate Perception Delay)

(8) Indicated Demand Growth Rate by Freight Rate Change = Perceived Freight Rate Change*Freight Rate Sensitivity on Indicated Demand

(9) Perceived Freight Rate Change = SMOOTH (Freight Rate Change Trend ,Freight Rate Perception Delay)

(10) Freight Rate Change Trend = TREND(Freight Rate, Average Time Interval for Trend Estimation , Initial Perceived Price Change)

6.4.3 Freight Rate Sector

The freight rate sector captures how the freight rate of container shipping service is determined and calculates the profitability of carriers. It is formulated that the freight rate is the function of either utilization or utilization change trend. Figure 6-17 shows the structure of freight rate sector.

The inputs to this sector from other sectors are unit total cost, unit variable cost, demand, and containership capacity. In addition, the exogenous parameters include initial freight rate, time to adjust freight rate, reference utilization, time to perceive utilization, voyage TAB (i.e., the number of voyages per year), average time interval for trend estimation of utilization change, initial perceived utilization change trend, and utilization perception delay. A nonlinear relationship between relative utilization and indicated freight rate is controlled by the table function, "TAB – Relative Utilization on Freight Rate." The detailed equations in the freight rate sector are shown in the following.

(11) Freight Rate Change Trend = INTEG (Change in Freight Rate, Initial Freight Rate)

(12) Change in Freight Rate = (Indicated Freight Rate-Freight Rate)/Time to Adjust Freight Rate

(13) Indicated Freight Rate = MAX(Minimum Freight Rate, Freight Rate*"Adj. Effect of Relative Utilization on Freight Rate")

(14) Minimum Freight rate = Unit Variable Cost

(15) Adj. Effect of Relative Utilization on Freight Rate = IF THEN ELSE (Effect of Utilization Change Trend on Freight Rate = 0, Effect of Relative Utilization on Freight Rate, Effect of Utilization Change Trend on Freight Rate)

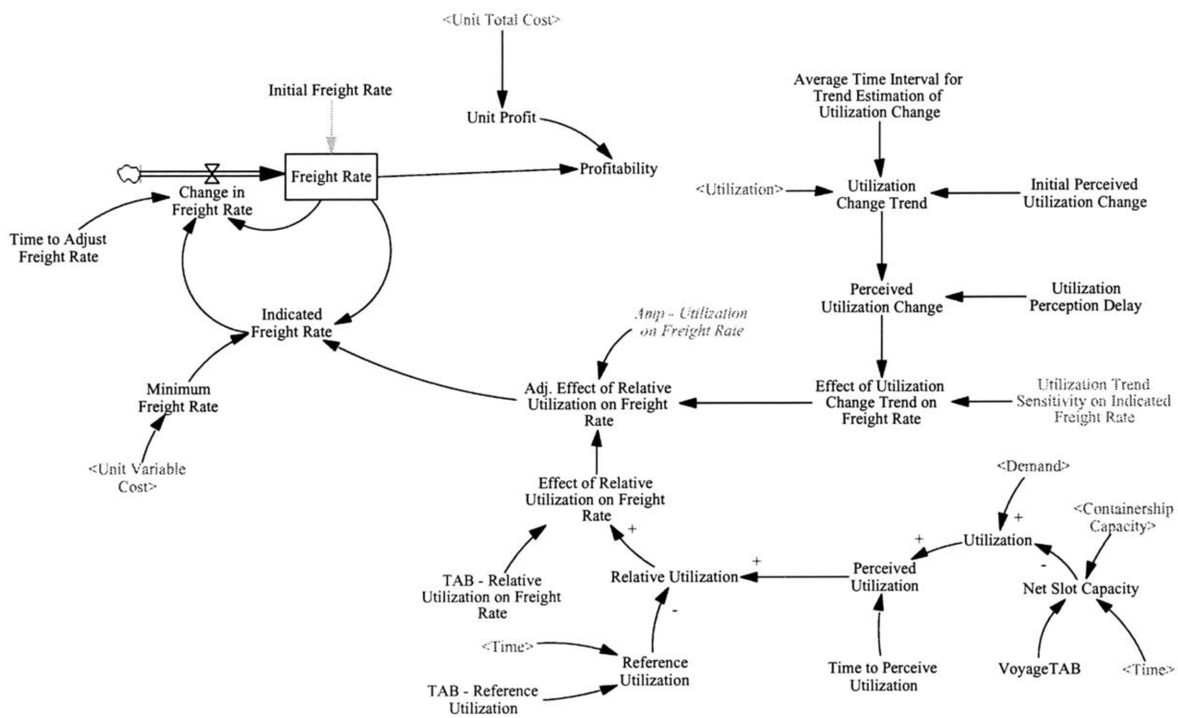


Figure 6-17 Structure of Freight Rate Sector

(16) Effect of Utilization on Freight Rate = "TAB - Relative Utilization on Freight Rate"(Relative Utilization)

(17) Relative Utilization = Perceived Utilization/Reference Utilization

(18) Reference Utilization = "TAB - Reference Utilization"(Time)

(19) Perceived Utilization = SMOOTH(Utilization, Time to Perceive Utilization)

(20) Utilization = Demand / Net Slot Capacity

(21) Net Slot Capacity = VoyageTAB(Time)*Containership Capacity

6.4.4 Capacity Sector

The capacity sector simulates the development of containership capacity over time through a stock-management system (Sterman, 2000), which is widely accepted for modeling capital acquisition in the industry. Figure 6-18 shows the structure of capacity sector.

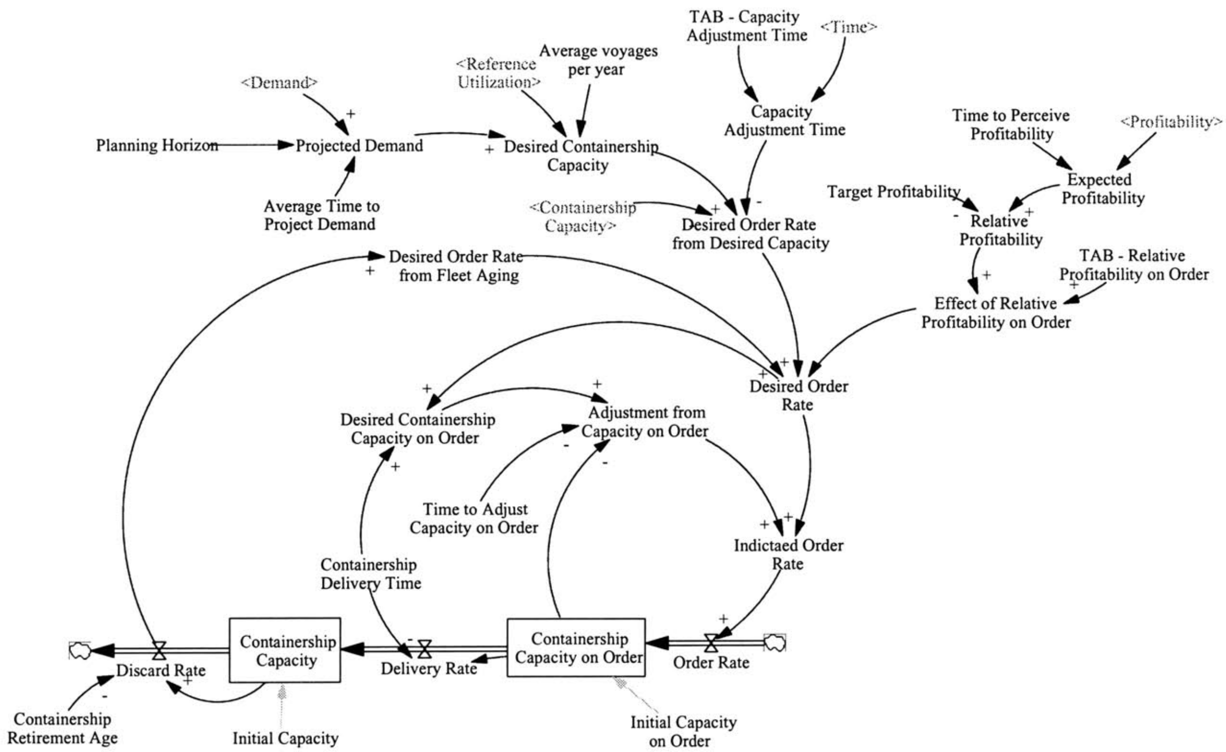


Figure 6-18 Structure of Capacity Sector

The inputs to this sector are demand and profitability, which are calculated from the demand sector and freight sector respectively. The exogenous parameters to this sector include initial capacity, initial capacity on order, containership delivery time, containership retirement age, time to adjust capacity on order, planning horizon, average time to project demand, average voyages per year, capacity adjustment time, reference utilization, target profitability, and time to perceive profitability. A nonlinear relationship between profitability and desired order rate is described by the table function of "TAB – Relative Profitability on Order,"

In this model, carriers are assumed to calculate the order rate based on two factors: desired order rate and adjustment from capacity on order. The desired order rate is determined by desired order rate from fleet aging, which is the amount of containerships ordered to replace the scrapped containership capacity; desired order rate from desired capacity, which is estimated from the projected demand and reference utilization; and effect of relative profitability on order, which increases the desired order rate if carriers' profitability is better than target profitability, and vice versa. Meanwhile, after estimating the desired order rate, carriers would consider the containership capacity on order (i.e. orderbook of containerships) to calculate the adjustment from capacity on order, and adjust the order rate. Detailed equations of this sector are provided below.

(22) Containership Capacity = INTEG (Delivery Rate – Discard Rate, Initial Capacity)

(23) Containership Capacity on Order = INTEG (Order Rate – Delivery Rate, Initial Capacity on Order)

(24) Order Rate = MAX (0, Indicated Order Rate)

(25) Indicated Order Rate = Desired Order Rate + Adjustment from Capacity on Order

(26) Desired Order Rate = (Desired Order Rate from Desired Capacity + Desired Order Rate from Fleet Aging) * Effect of Relative Profitability on Order

(27) Adjustment from Capacity on Order = (Desired Containership Capacity on Order-Containership Capacity on Order)/Time to Adjust Capacity on Order

(28) Desired Order Rate from Desired Capacity = (Desired Containership Capacity-Containership Capacity)/Capacity Adjustment Time

(29) Desired Containership Capacity = (Projected Demand / Reference Utilization) / Average voyages per year

(30) Projected Demand = FORECAST (Demand, Average Time to Project Demand, Planning Horizon)

(31) Desired Order Rate from Fleet Aging = Discard Rate

(32) Effect of Relative Profitability on Order = "TAB - Relative Profitability on Order"(Relative Profitability)

(33) Relative Profitability = Expected Profitability / Target Profitability

(34) Expected Profitability = SMOOTH(Profitability, Time to Perceive Profitability)

(35) Desired Containership Capacity on Order = Desired Order Rate*Containership Delivery Time

(36) Delivery Rate = Containership Capacity on Order / Containership Delivery Time

(37) Discard Rate = Containership Capacity / Containership Retirement Age

6.4.5 Cost Sector

This sector depicts the cost structure of container shipping service. Figure 6-19 shows the cost sector and detailed equations are provided in the following.

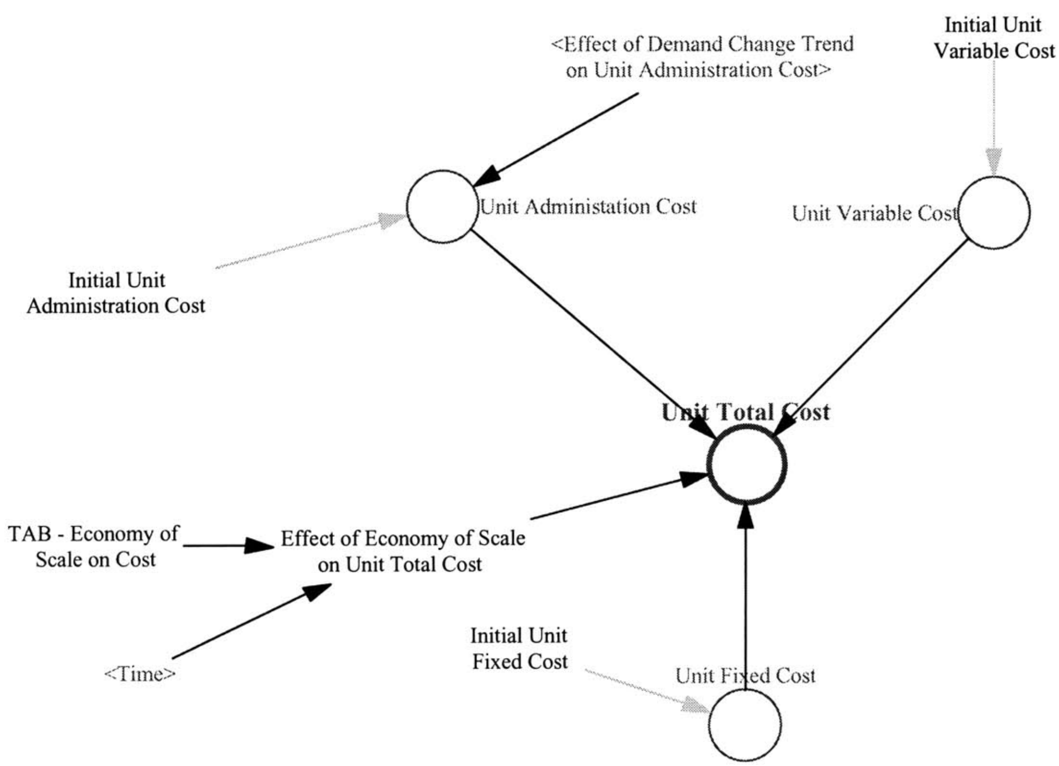


Figure 6-19 Structure of Cost Sector

(38) Unit Total Cost = (Unit Administrative Cost + Unit Fixed Cost + Unit Variable Cost) * Effect of Economy of Scale on Unit Total Cost

(39) Unit Administrative Cost = Initial Unit Administration Cost * Effect of Demand Change Trend on Unit Administration Cost

(40) Unit Fixed Cost = Initial Fixed Cost

(41) Unit Variable Cost = Initial Variable Cost

The unit cost of container shipping service, measured in dollar per TEU, comprises three components: unit fixed cost, unit variable cost, and unit administrative cost (Lim, 1994). The fixed cost includes the expenses for maintaining the containership fleet – for example, capital cost, depreciation, vessel expense, and crew expense – and is not a function of container shipping service provided. The variable cost is the direct costs of moving containers such as cargo expense, terminal handling charges, haulages, port charges, bunker expenses, etc., and is a function of a number of containers transported. The administrative cost is the indirect supporting cost of providing container shipping service – for instance, market research cost, sales cost, documentation cost, customer support cost, and other administrative cost.

The input to this sector is the effect of demand change trend on administrative cost, which is estimated from the demand sector. The exogenous parameters to this sector include initial administrative cost, initial fixed cost, initial variable cost, and effect of economy of scale on unit total cost. The output of this sector, unit total cost, is used for estimating the profitability of carriers in the freight rate sector.

6.5 Model Validation

This section describes a study to validate empirically the proposed model of dynamics of supply-and-demand in the container shipping industry. A brief summary of model validation methodology in system dynamics modeling is first presented. Next, data and parameters used for validating the model are explained. Finally, the empirical calibration processes of the model to the industry data in the 1990s are illustrated, followed by the validation of estimated parameters from interviews with industry veterans.

6.5.1 Model Validation Methodology

Once a model is developed, the model should be validated before it is used for policy analysis and design. Unless a model is considered valid, any further analysis with the model may be meaningless. Therefore, any model must be validated with the appropriate measures.

Model validation in system dynamics has been a complicated topic (Barlas, 1989, 1996) . Because system dynamics models are by nature "causal-descriptive" (theory-like, "white-box"), which illustrates how real systems actually operate in some aspects, generating an "accurate" output behavior is not sufficient for model validity; what is crucial is the validity of the internal structure of the model. A white-box model, being a "theory" about the real system, must not only reproduce/predict its behavior, but also explain how the behavior is generated, and possibly suggest ways of changing the existing behavior. However, validating the internal structure of the model cannot be entirely objective, formal, and quantitative; Rather, it can be subjective, informal, and qualitative. Therefore, it is hard to validate a system dynamics model in a formal way.

Given the difficulty of model validation in system dynamics, it is widely accepted in system dynamics that model validation be a gradual process of "confidence building" with respect to the "purpose of model," rather than a binary "accept/reject' divisions (Barlas, 1996; Forrester, 1961, 1968); i.e., validity of a system dynamics model cannot be discussed without reference to a specific purpose (Oliva, 1996).

To summarize the model validation process in system dynamics, Barlas (1996) proposed two steps of model validation process for a system dynamics model: The logical order of validation is first to test the validity of the structure (structure validity) with respect to the model purpose, and then start testing the behavior accuracy (behavior validity). In the structure validity, models should explain the real system with causal links embedded in the model. The validity of the model structure is assessed by direct comparison with knowledge about the real system structure. Causal loop diagrams are often useful ways of testing the structure validity. Sometimes a simple test simulation is used to uncover potential structural flaws.

After passing the structure validity test, a model should be tested for behavior validity. The behavior validity is to measure how accurately the model can reproduce the major behavior patterns exhibited in the real system. It is crucial to note that the emphasis is on *pattern* prediction (periods, frequency, trends, phase, lags, amplitudes, etc.), rather than point (event) prediction (Barlas, 1996). As long as a system dynamics model can reproduce the patterns of the real system, it is considered as passing the behavior validity test.

A system dynamics model developed for dynamics of supply-and-demand in the container shipping industry is regarded as passing the structure validity test. The reasons for this are as follows: First, the causal relationships, on which the model is based, are adapted from the generic causal links of supply-and-demand in the market economic system, which are well recognized and widely accepted in system dynamics (Sterman, 2000). Second, Weil's model on the airline industry, which the model on the container shipping industry is rooted on and generic causal links of supply-and-demand are embedded in, shows strong structure validity compared with the real system. Third, after calibrating the model with the real system, the model structures and key parameters were consulted with industry veterans to ensure the structure validity of the model. As shown in the later sections, the industry veterans generally agree with the model structures and accept the values of estimated parameters. Accordingly, the model for dynamics of supply-and-demand in the container shipping industry developed in the research can be considered as passing the structure validity.

Since the model has passed the structure validity test, it should now be tested with behavior validity in order to be used for further policy analysis. Testing the behavior validity is explained in the following, starting with a discussion on the data collection followed by the calibration process.

6.5.2 Data Collection and Parameter Estimation

In order to calibrate the model, input data should be collected first. There are four types of data to be collected: exogenous input variables, reference points for decision-making, information delay time, and nonlinear relationships. The data are collected from various industry resources (journal papers, analyst reports, industry magazines, etc.) and interviews with industry veterans. When the data for variables are not available, the best judgment for each variable is used in the trial simulation and modified later, if necessary, in order to provide better calibration result.

6.5.2.1 Exogenous Input Variables

The exogenous input variables set the initial condition of the model and draw the boundary of the model. Examples of exogenous input variables to this model include initial capacity, initial capacity on order, initial unit costs (fixed, variable, and administrative), initial demand, initial freight rate, initial perceived changes (demand, price, and utilization), GDP growth rate, Voyage TAB (i.e., number of voyages per year), average voyages per year, containership delivery time, and containership retirement age. The values of each exogenous input variable, its unit, and its source are presented in Table 6-2, Figure 6-20, and Figure 6-21.

Table 6-2 - Exogenous Input Variables

Variable Name	Value	Unit	Descriptions and Source
Initial Capacity	1.78 million	TEU / Year	Clarksons Research Studies (2001)
Initial Capacity on Order	154,000	TEU / Year	Clarksons Research Studies (2001)
Initial Demand	10.4 million	TEU / Year	Drewry Shipping Consultants (1999)

Variable Name	Value	Unit	Descriptions and Source
Initial Freight Rate	1,539	$ / TEU	Conference freight rate in 1990 from *Lloyd's Shipping Economist*, adjusted by the freight rate extrapolated from 1994, 1995, and 1996
Initial Unit Total Cost	1,492	$ / TEU	Estimated by assuming 5% of profitability and the break-down of total cost came from Lim (1994)
Initial Unit Variable Cost	965	$ / TEU	
Initial Unit Fixed Cost	219	$ / TEU	
Initial Administrative Cost	278	$ / TEU	
Initial Perceived Demand Change	0	1 / Year	Initial perceived demand change to be used for estimating the trend of demand change. It is assumed to be zero.
Initial Perceived Price Change	0	1 / Year	Initial perceived price change to be used for estimating the trend of price change. It is assumed to be zero.
Initial Perceived Utilization Change	0	1 / Year	Initial perceived utilization change to be used for estimating the trend of utilization change. It is assumed to be zero.
Average Voyages per Year	6.8	Dimensionless	Estimated from demand and capacity data in the Drewry Shipping Consultants (1999)
Containership Delivery Time	1.55	Years	Average time to build a containership. It is estimated around 18 months from calibration process and confirmed with industry veteran.
Containership Retirement Age	100	Years	Although containerships are usually used for 25 years, the calibration process make the model be set with 100 years of service time of containerships. Detailed will be explained in the calibration section.

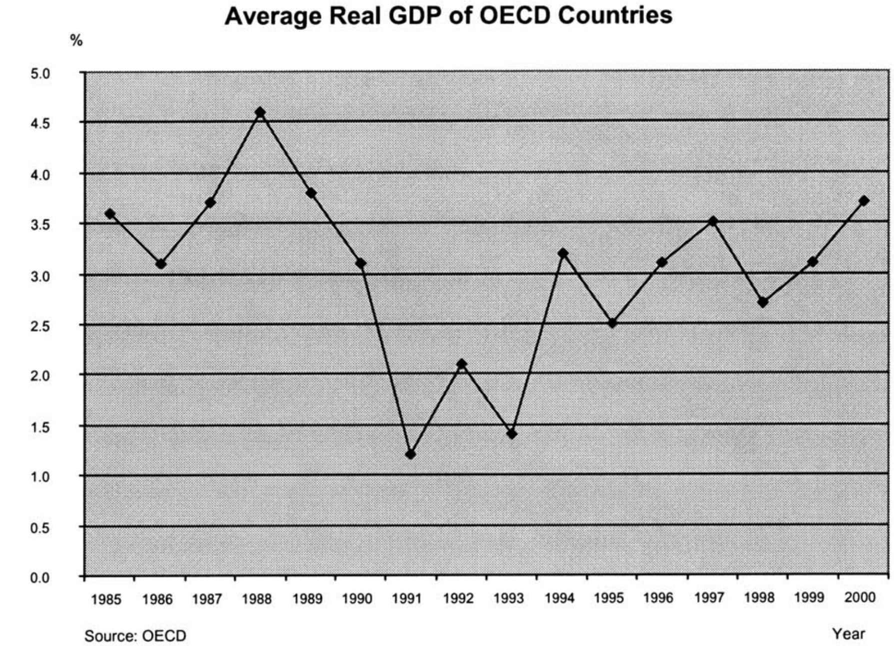


Figure 6-20 GDP Growth Rate

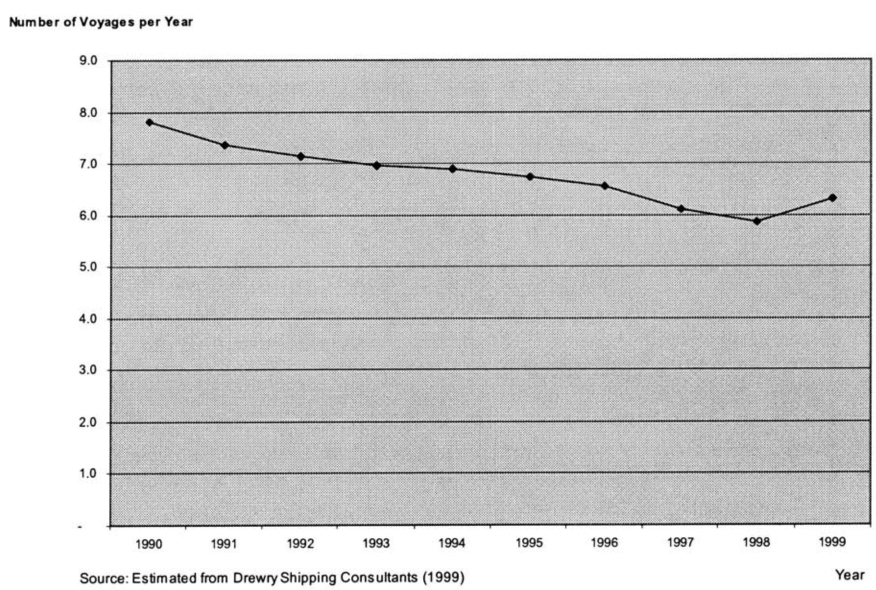


Figure 6-21 Number of Voyages per Year

6.5.2.2 Reference Points for Decision-making

Data for reference points for decision-making are the variables that carriers perceive in their mental models to make managerial decisions. Examples include reference utilization, planning horizon, capacity adjustment time, and target profitability. Descriptions, values, units, and sources of the data for reference points are provided in Table 6-3.

Table 6-3 Data for Reference Points for Decision-making

Variable Name	Value	Unit	Descriptions and Source
Reference Utilization	0.75 – 0.86	Dimensionless	Target utilization on which carriers decide to increase/decrease freight rate and invest in new containership capacity. Confirmed with industry veterans. For further information, look at Figure 6-22 below.
Planning Horizon	14.44	Years	The number of years that carriers consider when they estimate desired containership capacity in the future. Derived from calibration and confirmed with industry veterans.
Capacity Adjustment Time	4 – 4.25	Years	The time period that carriers would like to catch up with desired container capacity. It has been shorter over time by constructing bigger containerships in the mid 1990s. Estimated from interview and calibration.
Target Profitability	0.0642	Dimensionless	A reference profitability on which carriers decide to increase/decrease the order rate of containership capacity. Assumed to be average industry profitability in the 1990s.

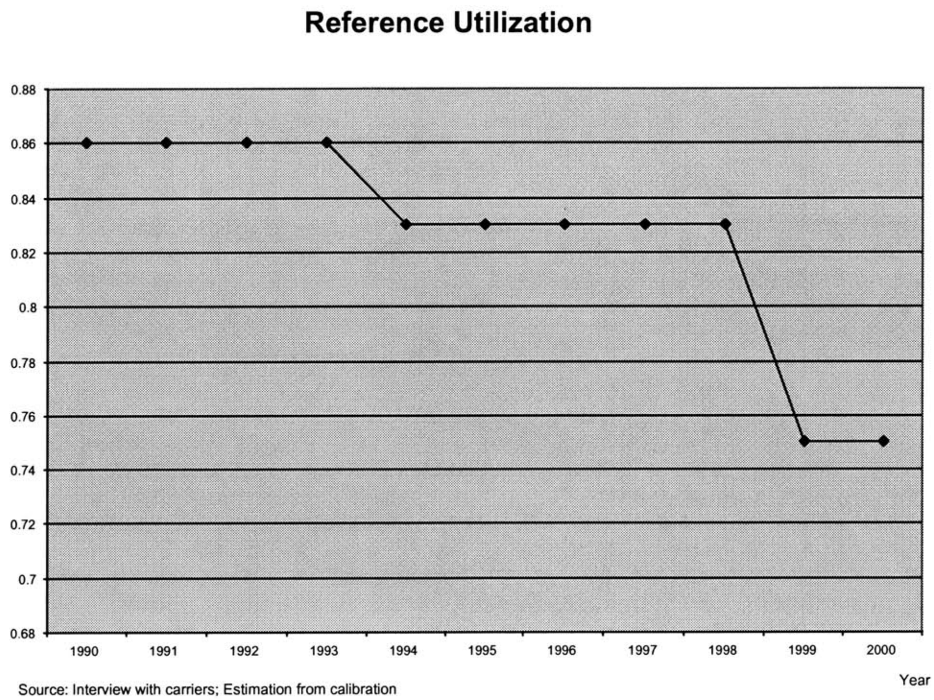


Figure 6-22 Reference Utilization

6.5.2.3 Information Delay Time

When carriers determine managerial decisions, they should wait or spend some time to process and digest the information that is used for the decisions. This information delay constitutes another important parameter to be considered in the system dynamics modeling. Examples of the information delay time in the container shipping industry include GDP growth rate perception delay, freight rate perception delay, demand adjustment delay, average time interval for trend estimation, average time interval for trend estimation of utilization change, time to adjust freight rate, utilization perception delay, time to perceive utilization, average time to project demand, time to adjust capacity on order, and time to perceive profitability. Because data for the information delay time are information processing time, it is often hard to estimate the delay time precisely. Many of the data for information delay time are therefore estimated by the best judgment or by the calibration process if they are important for the calibration purpose. Detailed descriptions of these parameters are presented in Table 6-4.

Table 6-4 Data for Information Delay Time

Variable Name	Value	Unit	Descriptions and Source
GDP Growth Rate Perception Delay	0.25	Years	Time to perceive the GDP growth rate. It is assumed to take a quarter year for market participants to know the GDP growth rate.
Freight Rate Perception Delay	0.1	Years	Time for shippers to perceive the change of freight rate. It is assumed to be around a month to perceive the freight rate change.
Demand Adjustment Delay	0.5	Years	Time for shippers to actually change the demand of container shipping based on the indicated demand. It is assumed to be 6 months to adjust.
Average Time Interval for Trend Estimation	1	Years	Time periods that shippers look at for estimating the change of freight rate. It is assumed to be 1 year.
Average Time Interval for Trend Estimation of Utilization Change	0.264	Years	Time periods that carriers look at for estimation the change of utilization. It is estimated from calibration process.

Variable Name	Value	Unit	Descriptions and Source
Time to Adjust Freight Rate	1	Years	Time for carriers to change the freight rate in accordance with indicated freight rate. It is estimated to be one year from calibration process and confirmed with current industry practice.
Utilization Perception Delay	0.033	Years	Time for carriers to perceive the utilization change. It must be relatively shorter than other delays because carriers always track the utilization change closely. It is estimated to be around 12 days from calibration process.
Time to Perceive Utilization	0.083	Years	Time for carriers to get to know the current utilization. It is assumed to be around a month.
Average Time to Project Demand	1	Years	Averaging time for past demand used in the projected demand. It is assumed to be 1 year following the Weil's model.
Time to Adjust Capacity on Order	0.2817	Years	Time over which carriers would like to adjust the amount of orderbook. The shorter, the more carriers consider the amount of orderbook for ordering new containership capacity. It is estimated to be around 3.3 months from calibration process.
Time to Perceive Profitability	0.5	Years	Time for carriers to calculate the expected profitability. It is assumed to be a half year.

6.5.2.4 Nonlinear Relationships

There are four table functions in the model to simulate the nonlinear relationships among the variables: effect of economy of scale on cost, effect of demand change trend on unit administration cost, effect of relative utilization on freight rate, and effect of relative profitability on order. Two of them – effect of economy of scale on cost and effect of demand change trend on unit administration cost – are exogenously input, while the rest are endogenously generated – i.e., interconnecting endogenous variables.

In reality, data for exact impact of economy of scale on cost in the container shipping industry are not readily available. In this model, therefore, the effect of economy of scale on cost is exogenously input by calibrating the simulated profitability with the real world profitability. It is estimated that economy of scale in the container shipping industry have reduced the total unit cost of container shipping to a level of 80% over the past 10 years (see Figure 6-23).

In addition, data for exact effect of demand change trend on unit administration cost are not available either. Reasonable assumptions are made for this relationship: If the demand change trend is less than 10%, the impact is assumed to be minimal, i.e., 1.5% impact on unit administration cost. However, for the demand change trend is larger than 10%, the impact is assumed to be substantial (Figure 6-24).

The rest of nonlinear relationships – effect of relative utilization on freight rate and effect of relative profitability on order – are estimated from the calibration process and presented in Figure 6-25 and Figure 6-26.

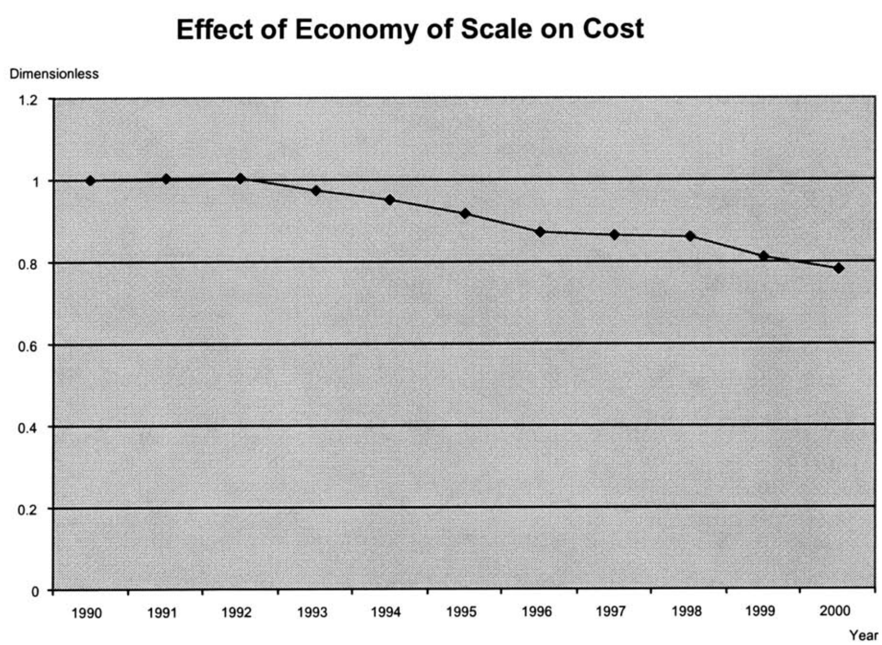


Figure 6-23 Effect of Economy of Scale on Cost

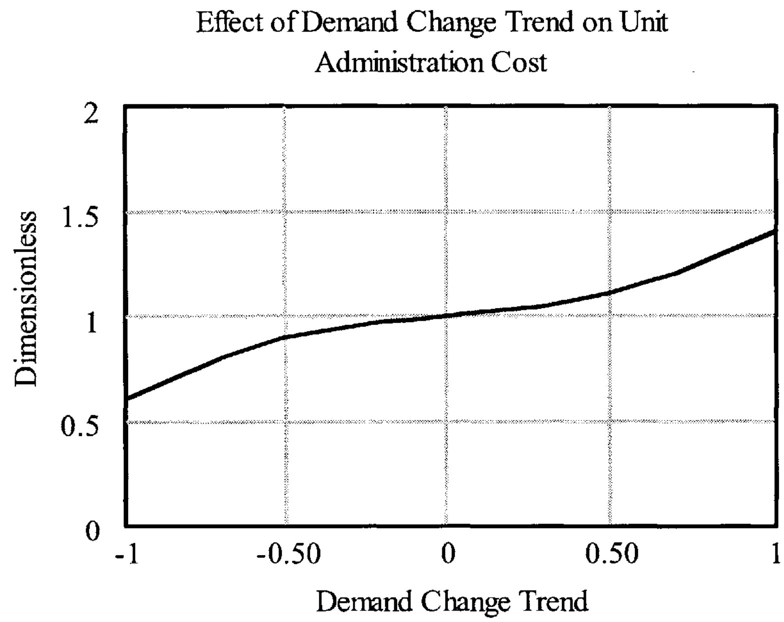


Figure 6-24 Effect of Demand Change Trend on Unit Administration Cost

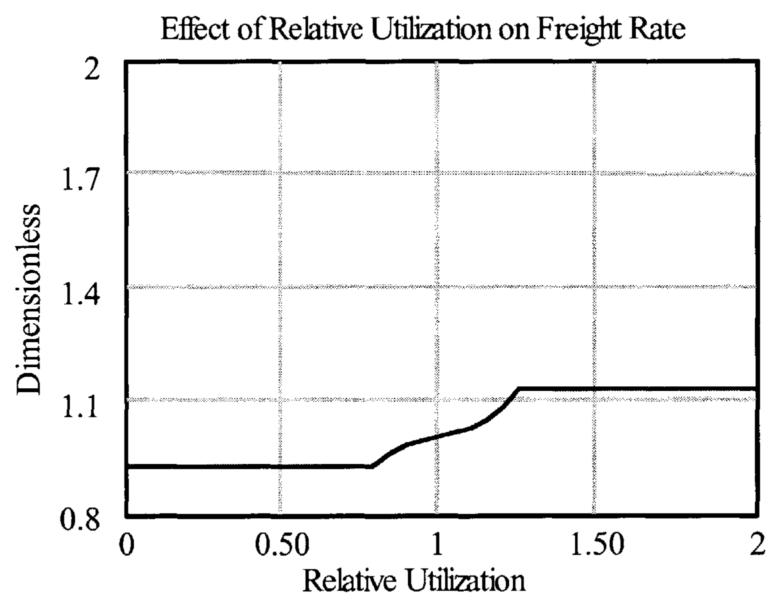


Figure 6-25 Effect of Relative Utilization on Freight Rate

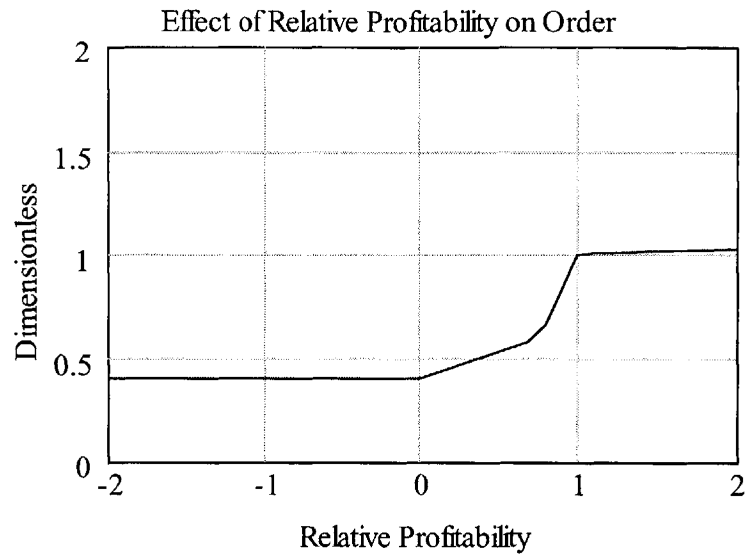


Figure 6-26 Effect of Relative Profitability on Order

6.5.3 Empirical Calibration of the Model

After collecting the data for exogenous parameters, the model can now be calibrated to the real industry data in order to ensure the behavior validity. In other words, for the behavior validity, simulation results from the model should successfully regenerate the behavior of historical industry data.

For the calibration purpose, nonlinear least squares estimation using Powell's (1969, 1972) optimization algorithm as implemented in Vensim® is used in this research. Two sets of variables should be chosen for calibration: variables for objective functions and variables for constraints. The variables for objective functions are important industry data that characterize the dynamics of supply-and-demand in the container shipping industry. Meanwhile, the variables for constraints are selected based on two factors: (1) the variables should be critical in determining state variables in the model; (2) data for the variables, however, are not readily available from industry sources so that they should be estimated indirectly. Eight variables are selected for objective functions whereas twelve variables are chosen for constraints (Table 6-5). All exogenous parameters are set to the values estimated in 6.5.2, and the model is initialized to reflect the status of container shipping industry in 1990.

The summary statistics for the historical fit of the model[47] to the real industry data are shown in Table 6-6, and Figure 6-27 shows the behavior of the simulated data against the historical series.

Table 6-5 Objective Functions and Constraints for Calibration

Variables for Objective Functions	Variables for Constraints
• Demand	• GDP Sensitivity on Indicated Demand
• Freight Rate	• Freight Rate Sensitivity on Indicated Demand
• Containership Capacity on Order	• Effect of Relative Profitability on Order
• Containership Capacity	• Effect of Relative Utilization on Freight Rate
• Order Rate	• Effect of Economy of scale on Cost
• Delivery Rate	• Time to Adjust Capacity on Order
• Utilization	• Time to Adjust Freight Rate
• Profitability	• Containership Delivery Time
	• Planning Horizon
	• Utilization Perception Delay
	• Utilization Trend Sensitivity on Indicated Freight Rate
	• Average Time Interval for Trend Estimation of Utilization Change

[47] A Vensim module to calculate the summary statistics for the fit between the simulated and historical time series is used (Oliva, 1995).

Table 6-6 Historical Fit of the Model

Variable Name	Data Points	R^2	MAPE	Theil's Inequality Statistics		
				Bias	Unequal Variation	Unequal Covariance
Demand	10	0.985	2.0%	0.302	0.042	0.656
Containership Capacity	10	0.995	2.1%	0.106	0.001	0.893
Containership Capacity on Order	8	0.611	15%	0.091	0.012	0.897
Order Rate	9	0.748	42.6%	0.062	0.475	0.463
Delivery Rate	9	0.582	28.6%	0.363	0.018	0.619
Utilization	10	0.823	1.8%	0.082	0.001	0.917
Freight Rate	7	0.775	3.4%	0.026	0.204	0.770
Profitability	10	0.891	5.6%	0.016	0.452	0.532

The simulation results show that the model tracks the historical industry data quite well. Most of the Mean Absolute Percent Error's (MAPE) between the simulated and actual data are less than 6% except those of containership capacity on order, order rate, and delivery rate, indicating a close fit of the model to the actual behavior of the container shipping industry. In addition, the low bias and variation components of the Theil's inequality statistics indicate that errors are unsystematic (Sterman, 1984, 2000).

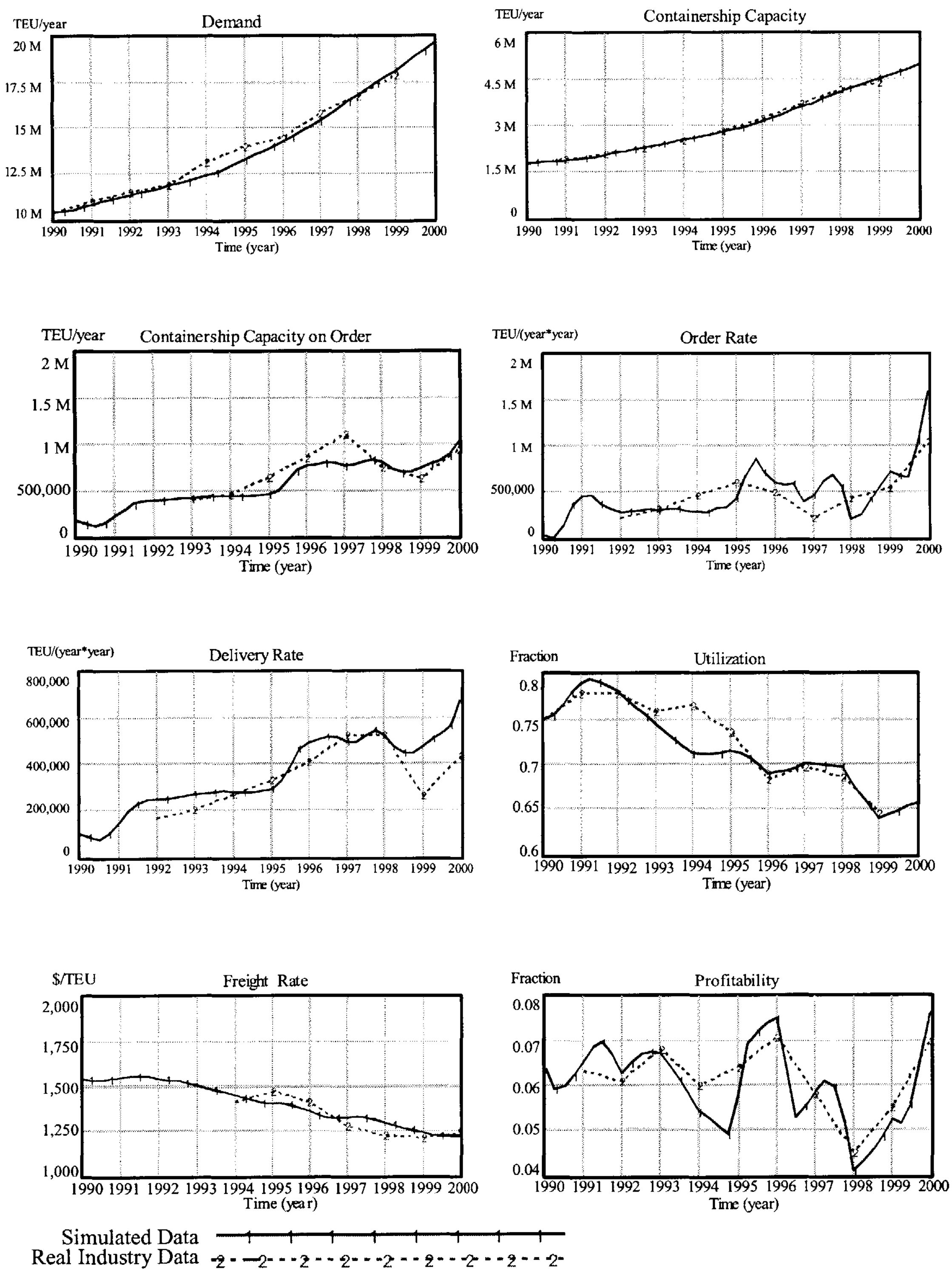


Figure 6-27 Model Calibration: Historical Fit of Model

6.5.4 Validation of Estimated Parameters

The empirical calibration of the model in section 6.5.3 shows that the model for dynamics of supply-and-demand in the container shipping industry successfully simulates the historical behavior of the industry variables. In addition to the behavior validity of the model, the estimated parameters of the model were discussed with industry veterans in order to increase the confidence of the model.

Although general structures of the model are reconfirmed through interviews with industry veterans, four parameters are rechecked in particular (Table 6-7). The interviews confirm that the model structure for dynamics of supply-and-demand in the container shipping industry is acceptable and understandable, and the estimated parameters are reasonable.

Table 6-7 Validation of Estimated Parameters

Parameters	Value in the model	Interviewee	Comments on Parameters
Planning Horizon	14.44 years	Peter Keller, COO of NYK America	"We consider at least 10 years ahead before ordering containerships because the life cycle of containership is at least 20 years."
Target Profitability	6.42%	Peter Keller, COO of NYK America	"We tend to consider that 5% - 6% of operating margin is a threshold by which we determine our performance."
Containership Delivery Time	1.55 years (or 18.6 months)	Jae-shin Kim, Technical Manager Hyundai Heavy Industries	"It usually takes 18 months from signing contract with ship owners to delivering a containership to them."
Reference Utilization	75 ~ 86%	Peter Keller, COO of NYK America	"We start to consider increasing capacity if the utilization in transatlantic is around 85%, or 80% in transpacific trade routes."

6.6 Insights from the Modeling of the Container Shipping Industry

The model developed here is the first system dynamics analysis of the dynamics of supply-and-demand in the container shipping industry. The model successfully simulates the dynamic behavior of container shipping services – for example, increasing trend of supply and demand of container shipping service, different growth rates of supply and demand of container shipping service, decreasing trend of freight rate and utilization, and changing profitability of carriers.

In addition to simulating the behavior of the industry, the modeling process also reveals several insights into the container shipping industry, which helps one to understand the future dynamics of supply-and-demand in this industry. Notable insights from the modeling are provided in the following.

- Demand of container shipping service is more highly sensitive to GDP growth rate than to the changing trend of freight rate. The demand is approximately 4 times more sensitive to GDP growth rate than to changing trend of freight rate.

- Carriers might have used longer planning horizon (approximately 14 years) in the capacity planning, which in turn over-speculates the future demand and capacity thereby generating the chronic overcapacity problems.

- Orderbook of containership has been an important factor for capacity ordering decision, which is contrary to the general belief in the industry that carriers tend not to consider the current orderbook of containership in capacity planning.

- The ordering of containerships for replacing the capacity scrapped has been minimal. The reason for this is that the capacity of early containerships, which were built in the early 1960s and started to be scrapped from the 1990s, is minimal compared with current capacity level. However, as more containerships reach the maximum age of service life over time, the impact of containership capacity scrapped on capacity ordering will become more important.

- Reference utilization, by which carries would increase or decrease freight rate and determine the desired containership capacity, must have been decreasing over time to reflect the decreasing cost structure of container shipping service due to the economy of scale

6.7 Conclusions

This chapter has presented a system dynamics model for dynamics of supply-and-demand in the container shipping industry. Overall, the model was able to explain the causal linkages driving the dynamic behaviors of industry variables and simulate the dynamic behaviors of industry variables in the 1990s, thus increasing our confidence of the structure and behavior validity of the model. Given the confidence of the model, it now can be used as a reference system to test the impacts of e-business on the container shipping industry, which is explored in the following chapters.

Chapter 7 Modeling the Diffusion Dynamics of EDI in the Container Shipping Industry

7.1 Introduction

In Chapter 1, the evolution of EDI in the container shipping industry was closely analyzed in order to better understand the impacts of e-business on the container shipping industry. Since EDI and internet technology have similar technical characteristics such as network externality, a profound analysis on the diffusion dynamics of EDI could provide useful insights into the impacts of e-business on the container shipping industry. Hence, a system dynamics model simulating the diffusion dynamics of EDI in the container shipping is developed in this research.

This chapter is organized as follows: a brief summary of previous research on modeling of technology diffusion is first presented. Section 7.3 illustrates the causal relationships that drive the diffusion dynamics of EDI in the container shipping industry. Next, section 7.4 explains a system dynamics model for diffusion dynamics of EDI in the container shipping industry, followed by the model validation through empirical calibration of the model in section 7.5.

7.2 Previous Research on the Modeling of Technology Diffusion

The diffusion or adoption of new technologies or products is a critical factor in the success of any technology-based company. Successful adoption of a new technology can give a company a significant advantage over competitors, both in terms of the opportunity to lead the technological innovation and in terms of the ability to drive down costs ahead of the competition. Understanding the diffusion dynamics of new technologies is therefore very important.

A number of theories and models have been developed to improve the understanding of dynamics of technology diffusion. In particular, because the diffusion or adoption of new technology often follows the S-shaped patterns, many models have been proposed to simulate the S-shaped diffusion patterns of new technology.

The first attempt to simulate the S-shaped growth was to develop analytic models. The analytic models provide simple analytic equations, which can generate S-shaped growth patterns, so that they are easy to understand and calculate. Examples of this analytic model include the logistics growth model, the Richards model, the Gompertz model, the Weibull model, and the Fisher-Pry model (Fisher and Pry, 1971; Richardson, 1991; Sterman, 2000; Walk, 2002). Because the analytic models are simple and successfully simulate any S-shaped growth behaviors, they are also widely used for quantitative technology forecasting (Vanston, 2002). However, since the models have strict assumptions to derive the analytic solutions, they are not flexible enough to consider more realistic situations encountered in the real world dynamics.

In order to overcome the shortcomings of analytic models, Bass (1969) proposed a model for the diffusion of innovation, It took the form (Then, 2001):

$$dN/dt = (a + bN_a)\,(N_p - N_a)$$

where N_a = the number of adopters

N_p = the number of potential adopters

a = coefficient of innovation

b = coefficient of imitation

The Bass model was based on the notion that potential adopters can be persuaded to become adopters as a result of interactions either internally or externally to the network of adopters. If a = 0 in this equation, it is as same as the logistics growth model and all adoptions come from internal source of word-of-mouth. If b = 0, the exponential model is in effect and all adoptions come from external source such as advertising.

The Bass model has become one of the most popular models for diffusion of new technology and is widely used in marketing, strategy, management of technology, and other fields (Sterman, 2000). In addition, many extensions of the Bass model to include more realistic conditions have been developed. Particularly, many extended versions of the Bass model can be easily developed through the system dynamics modeling methodology (Sterman, 2000).

Meanwhile, a general system dynamics model to simulate the technology diffusion has been proposed by Lyneis. The Lyneis model attempts to produce the simulation results that are consistent with several existing forecasting and assessment techniques for the technology diffusion, including (1) ability to generate S-curve to demonstrate technology progress; (2) cost-experience curves and their influence on pricing strategy; (3) price-performance curves; (4) diffusion or product life cycle curves deploying the concept of lead users to laggards; and (5) substitution curves developed consistent with the Fisher-Pry model.

7.3 Causal Relationships for the Diffusion Dynamics of EDI in the Container Shipping Industry

The analysis of diffusion dynamics of EDI in the container shipping industry estimates an S-shaped diffusion curve of EDI – i.e., the EDI diffusion rate by users, which is the number of EDI users divided by the total players in the container shipping industry, is S-shaped, starting from the early 1990s and saturating around 50% in the year of 2000 (Figure 7-1). Modeling the S-shaped diffusion curve of EDI could help understand the dynamics of EDI diffusion in the container shipping industry.

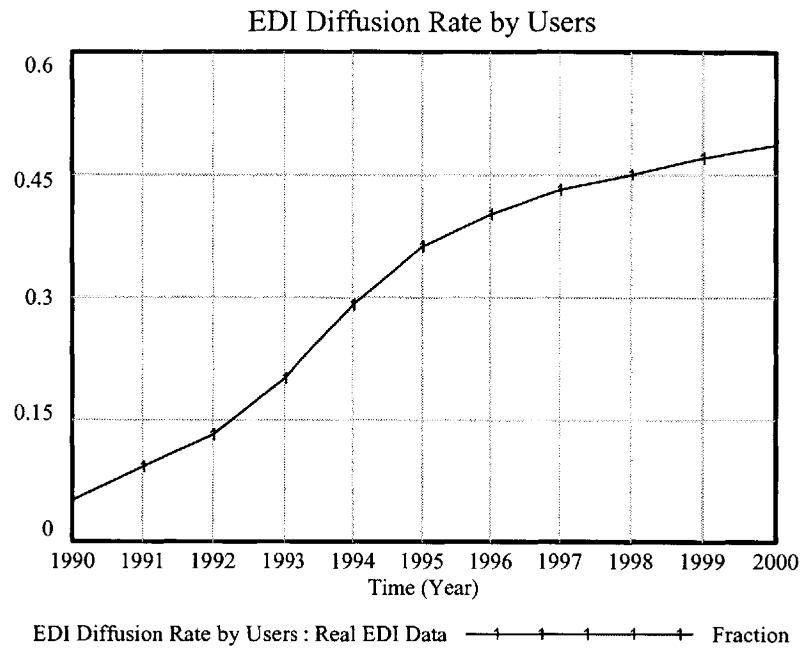


Figure 7-1 Real EDI Diffusion Rate in the Container Shipping Industry

(Source: Estimated from industry data and interviews, see the section 4.3.3)

Among the different models of technology diffusion, the Bass model is selected as a base model to simulate the diffusion dynamics of EDI in the container shipping industry. Specifically, a system dynamics version of the Bass model is developed for modeling the diffusion dynamics of EDI in the container shipping industry. Two main reasons drive this decision: First, the Bass model is most widely used for modeling the technology diffusion. Second, the system dynamics modeling methodology is more flexible than other modeling tools so that more realistic assumptions can be easily implemented in the model.

From a broader perspective, the diffusion dynamics of EDI in the container shipping industry can be modeled with three important feedback loops: balancing "trading partners' request" feedback loop, reinforcing "EDI benefits" feedback loop, and balancing "competitive advantage" feedback loop. Figure 7-2 shows the causal loop diagrams for the diffusion dynamics of EDI, and Table 7-1 provides the list of key variables used in the causal loop diagrams. Detailed explanations of each feedback loop are presented in the following.

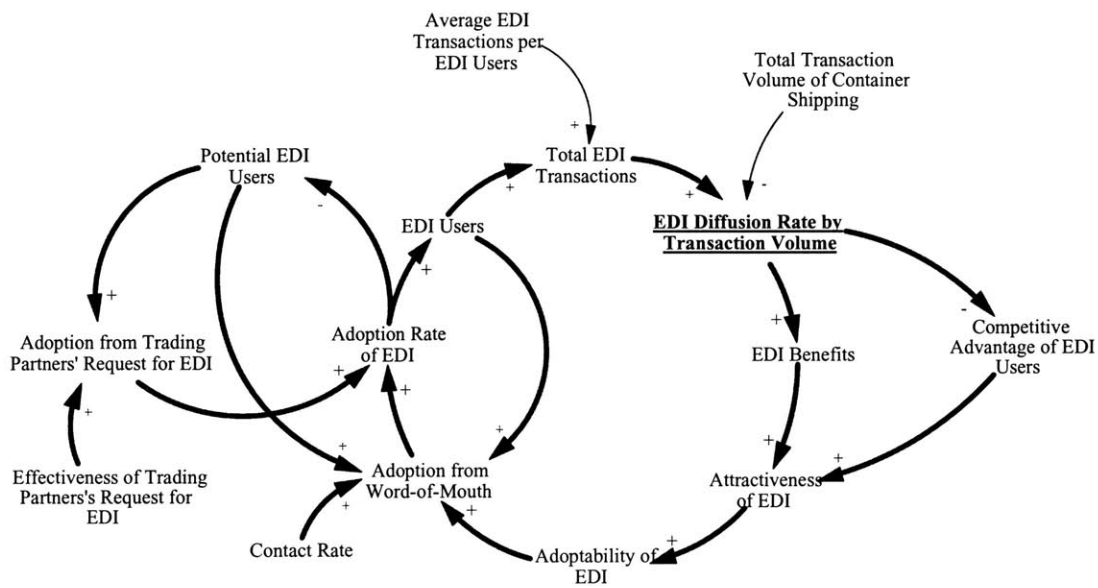


Figure 7-2 Causal Loop Diagrams for the Diffusion Dynamics of EDI in the Container Shipping Industry

Table 7-1 List of Variables in the Feedback Loops for the Diffusion Dynamics of EDI

Key Variables	Definition	Dimension	State Variable
Potential EDI Users	Potential number of EDI users in the container shipping industry	Company	Yes
EDI Users	The number of active EDI users in the container shipping industry	Company	Yes
Adoption Rate of EDI	The number of companies that adopt EDI per year	Company / year	
Adoption from Word-of-Mouth	The number of companies that adopt EDI per year by word-of-mouth process	Company / year	
Contact Rate	A rate that total players interact each other per year i.e., measured in company contacted per player per time year	1 / year	

Key Variables	Definition	Dimension	State Variable
Adoptability of EDI	A fraction that contacts between potential EDI users and EDI users make potential EDI users become active EDI users.	Dimensionless	
Attractiveness of EDI	The extent that EDI is attractive to the potential EDI users	Dimensionless	
Competitive Advantage of EDI Users	The extent of competitive advantage of EDI as a function of "EDI Diffusion Rate by Transaction Volume"	Dimensionless	
EDI Diffusion Rate by Transaction Volume	A fraction that business transactions are executed by EDI	Dimensionless	

7.3.1 Balancing "Trading Partners' Request" Feedback Loop

In the early days of EDI diffusion, few companies were willing to adopt EDI technology for their business purpose because EDI was little known to the industry players and expensive to implement. The major driver of EDI diffusion in the early days was the trading partners' request to adopt a new technology of EDI. Particularly, the large carriers and shippers, who anticipated huge cost-savings from EDI-based transactions, were the early adopters of EDI and actively urged their trading partners to join the EDI-based business activities. However, once the EDI became more popular among the industry, the impact of trading partners' requests to adopt EDI was relatively reduced because of the word-of-mouth impact, which is the process of exchanging the information on the benefit of EDI by interactions among potential EDI users and active EDI users.

This early dynamics of EDI diffusion can be explained by the balancing "trading partners request" feedback loop (see Figure 7-3). If the potential EDI users, who are willing to adopt EDI technology, are plentiful in the industry as in the early days of EDI diffusion, they tend to request other trading partners to adopt EDI. The increased adoption of EDI by the trading partners' request will then increase the adoption rate of EDI over time. Finally, the increased adoption rate of EDI will decrease the potential EDI users because many potential EDI users become active EDI users, thereby constructing a balancing feedback loop.

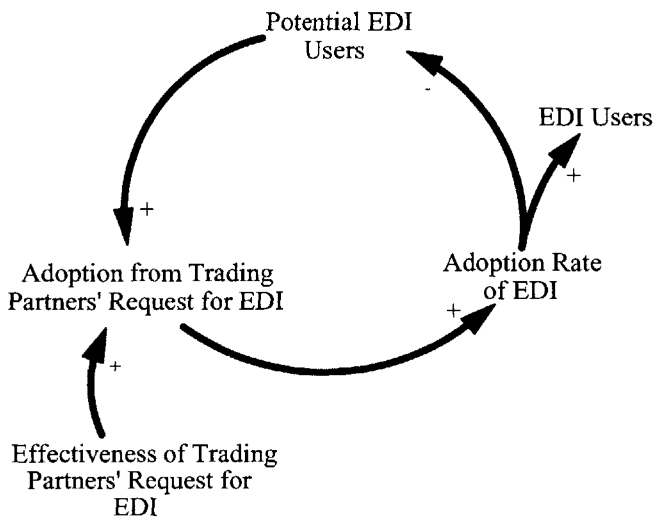


Figure 7-3 Balancing "Trading Partners' Request" Feedback Loop

7.3.2 Reinforcing "EDI Benefits" Feedback Loop

After passing the early slow diffusion of EDI, the container shipping industry saw a rapid growth of EDI diffusion in the mid 1990s. The major driver of this rapid diffusion of EDI was attributable to the better understanding of the benefits of EDI-based business transactions. Because the EDI technology could provide better productivity, less clerical errors, lower administrative costs, etc., the early adopters of EDI started to propagate the benefits of EDI to the potential EDI users and support the adoption of EDI actively. In other words, the reputation of EDI benefits let the adopters of EDI interact with potential EDI users by either telephone, mail, business meeting, etc., and persuaded them into adopting EDI. This process is so called "word-of-mouth" dynamics, where the adoption of EDI increased rapidly as the number of active EDI users and the EDI benefits increased.

This word-of-mouth dynamics can be modeled by the reinforcing "EDI benefits" feedback loop (see Figure 7-4). As the number of EDI users increases, the adoption of EDI from word-of-mouth will increase, thereby increasing the number of EDI users. In addition, the increased number of EDI users will increase the "EDI diffusion rate by transaction volume," which is measured by "total EDI transactions" divided by the "total transaction volume of container shipping." As more transactions in the container shipping industry are done by EDI, more benefits of EDI will be provided because of the positive network externality of EDI technology, and then the attractiveness of EDI will also improve. The improved attractiveness of EDI will then increase the "adoptability of EDI," which is the portion of contacts that are sufficiently persuasive to induce the potential EDI users to adopt the EDI. Finally, the increased adoptability of EDI will increase the adoption of EDI from word-of-mouth so that the number of EDI users will increase again, thereby constituting a reinforcing feedback loop.

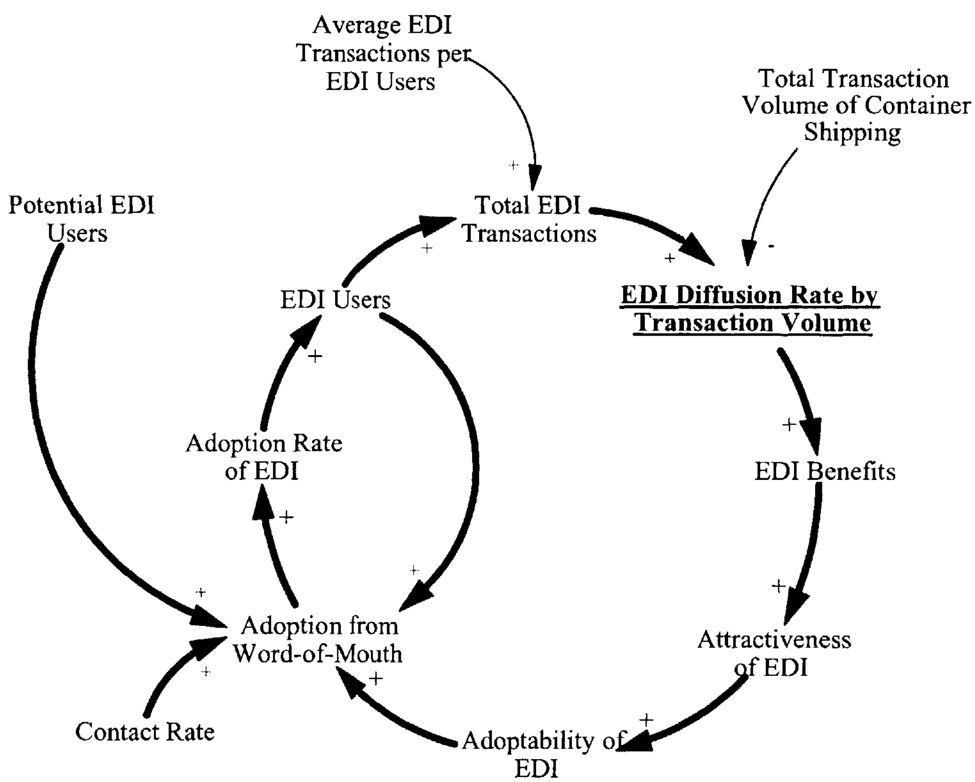


Figure 7-4 Reinforcing "EDI Benefits" Feedback Loop

7.3.3 Balancing "Competitive Advantage" Feedback Loop

The diffusion of EDI in the container shipping industry shows that the EDI diffusion rate by users, which is the ratio of active EDI users divided by potential EDI users, increases at a decreasing rate after experiencing rapid adoption of EDI. This slow increase of EDI diffusion rate was due to the decreasing competitive advantages from adopting EDI. In other words, because many competitors in the container shipping industry had already implemented the EDI technology, the relative competitive advantages of the late EDI adopters became lower than that of the early adopters, thereby the adoption of EDI became slower over time. The many small and medium enterprises (SMEs) in the container shipping industry, who were reluctant to adopt EDI due its high implementation cost, accordingly did not adopt EDI, resulting in a slow increase in EDI diffusion rate by users.

The dynamics can be modeled by the balancing "competitive advantage" feedback loop (see Figure 7-5). As the number of EDI users increases, the "EDI diffusion rate by transaction volume" increases. As more transactions are done through the EDI technology, the potential competitive advantage of the EDI adopters becomes lower so that the attractiveness of EDI decreases. This decreased attractiveness of EDI will subsequently lower the adoptability of EDI, thereby decreasing the adoption from word-of-mouth. Then, decreased adoption rate of word-of-mouth reduces the number of EDI users to complete the balancing feedback loop.

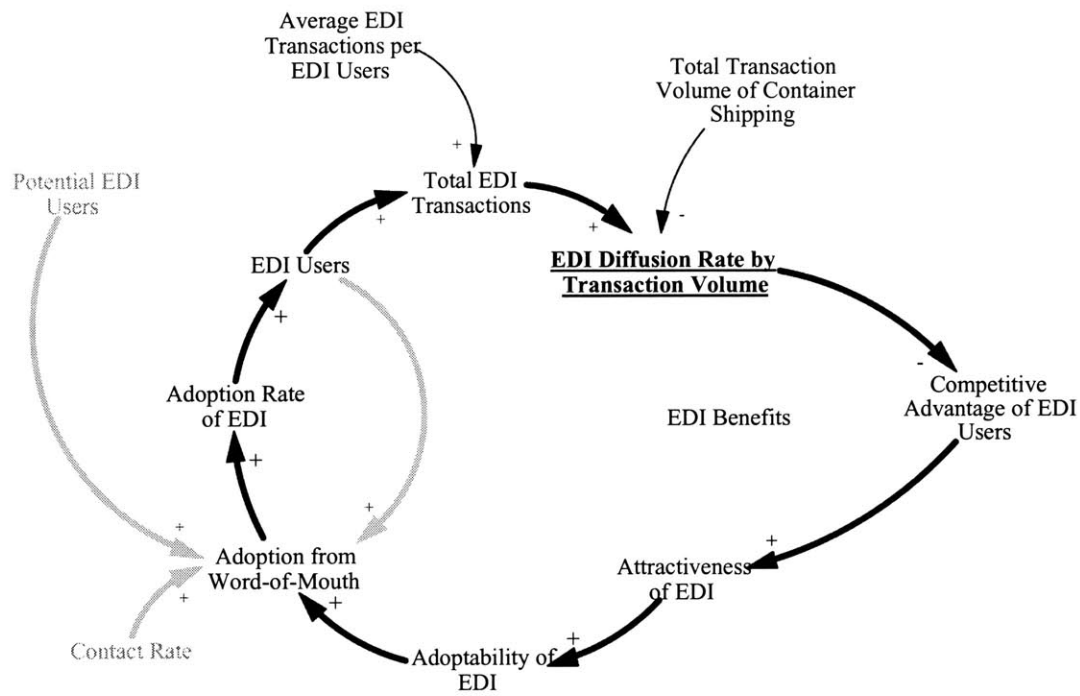


Figure 7-5 Balancing "Competitive Advantage" Feedback Loop

7.4 Model Structure

This section presents a formal description of a system dynamics model for the diffusion dynamics of EDI in the container shipping industry. The model is based on a system dynamics version of the Bass model (Sterman, 2000); however, several updates of the model structures were implemented to consider the causal relationships identified in section 7.3.

7.4.1 Purpose and Boundary of the Model

The purpose of the model for the diffusion dynamics of EDI is to understand the internal dynamics of EDI diffusion in the container shipping industry, and to simulate the historical behaviors of EDI diffusion in the 1990s. The model will be used as a reference system to simulate the potential diffusion of e-business in the container shipping industry in this research.

Table 7-2 shows the endogenous variables, the exogenous variables, and what is excluded in the model.

Table 7-2 Model Boundary Chart for the Model for the Diffusion Dynamics of EDI

Endogenous Variables	Exogenous Parameters	Excluded in the model
• Potential EDI users * • EDI users • Adoption rate of EDI • Adoption of EDI from word-of-mouth • Adoption of EDI from trading partners' demand for EDI • Adoptability • Attractiveness of EDI • Effect of attractiveness on adoptability • Effect of EDI benefits on attractiveness • Effect of relative competitive advantage on attractiveness • EDI diffusion rate by transaction volume • Total transactions • Total EDI transactions • EDI diffusion rate by users • Initial potential EDI users	• Total players • Initial EDI users • Contact rate • Effectiveness of trading partners' demand • Normal adoptability • Normal attractiveness • Container shipping demand • Average transactions per container shipping demand • Average EDI transactions per EDI users	• Growth in the size of total market

(*) The underlined variables are state variables in the model

For the purpose of presentation, the model is decomposed into two sectors: EDI diffusion sector and adoptability sector. The EDI diffusion sector describes how potential EDI users become active EDI users based on the adoption rate of EDI. The adoptability sector represents how the level of EDI adoption rate by transaction volume could determine the attractiveness of EDI, which then controls the adoptability of EDI.

7.4.2 EDI Diffusion Sector

The EDI diffusion sector models the adoption of EDI by potential EDI users. Following the Bass model, the adoption rate of EDI is assumed to be determined by two factors: trading partners' demand for EDI as an external source and word-of-mouth effect as an internal source. Figure 7-6 shows the stock and flow structure for the EDI diffusion sector.

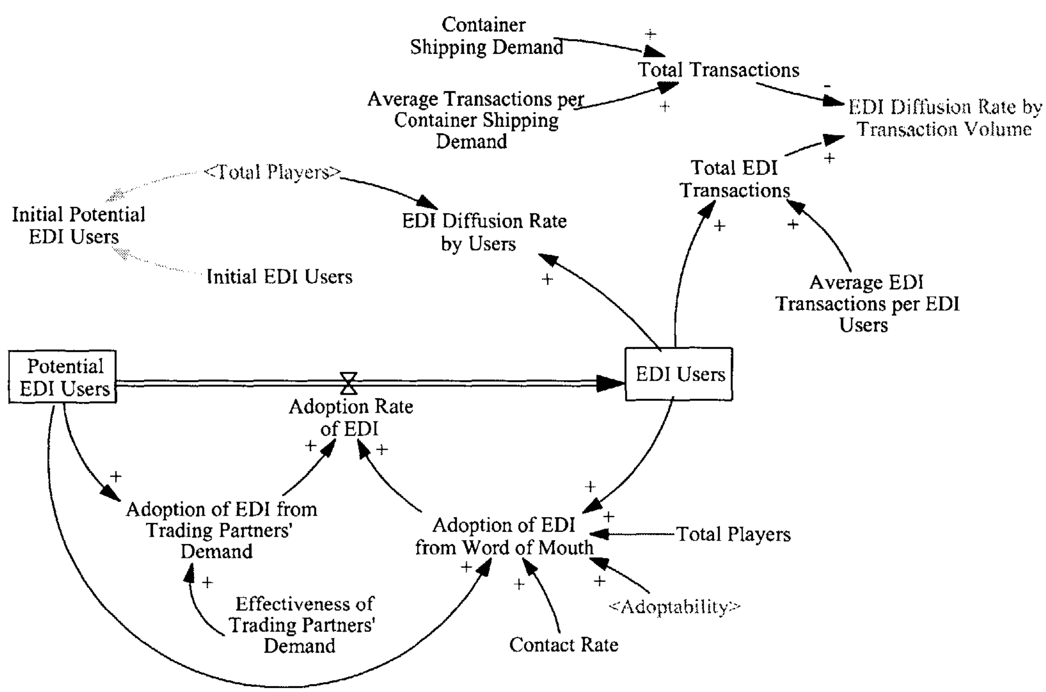


Figure 7-6 Structure of EDI Diffusion Sector

The main input to this sector is adoptability, which is calculated from the adoptability sector, and the exogenous parameters to this sector include total players, initial EDI users, contact rate, effectiveness of trading partners' demand, container shipping demand, average transactions per container shipping demand, and average EDI transactions per EDI users. The output from this sector is the EDI diffusion rate by transaction volume, which determines the effect of EDI benefits on attractiveness of EDI and the effect of relative competitive advantage on attractiveness of EDI in the adoptability sector. The detailed equations are explained in the following.

(1) Potential EDI Users = INTEG (- Adoption Rate of EDI, Initial Potential EDI Users)

(2) EDI Users = INTEG (Adoption Rate of EDI, Initial EDI Users)

(3) Adoption Rate of EDI = Adoption of EDI from Trading Partners' Demand + Adoption of EDI from Word of Mouth

(4) Adoption of EDI from Trading Partners' Demand = Potential EDI Users * Effectiveness of Trading Partners' Demand

(5) Adoption of EDI from Word of Mouth = (Potential EDI Users * Contact Rate) * (EDI Users / Total Players) * Adoptability

(6) Initial Potential EDI Users = Total Players – Initial EDI Users

(7) EDI Diffusion Rate by Users = EDI Users / Total Players

(8) EDI Diffusion Rate by Transaction Volume = Total EDI Transactions / Total Transactions

(9) Total EDI Transactions = Average EDI Transactions per EDI Users * EDI Users

(10) Total Transactions = Average Transactions per Container Shipping Demand * Container Shipping Demand

7.4.3 Adoptability Sector

The adoptability sector captures how adoptability of EDI is determined from the attractiveness of EDI, which in turn is impacted by the EDI diffusion rate by transaction volume. Figure 7-7 presents the structure of the adoptability sector.

The input to this sector is the EDI diffusion rate by transaction volume, which is estimated from the EDI diffusion sector, and the exogenous parameters are normal attractiveness of EDI and normal adoptability. The output from this sector is the adoptability, which is the input to the EDI diffusion sector. Three nonlinear relationships are described in the table functions of "TAB – EDI Benefits on Attractiveness," "TAB – Relative Competitive

Advantage on Attractiveness," and "TAB – Attractiveness on Adoptability." The detailed equations in the adoptability sector are shown in the following.

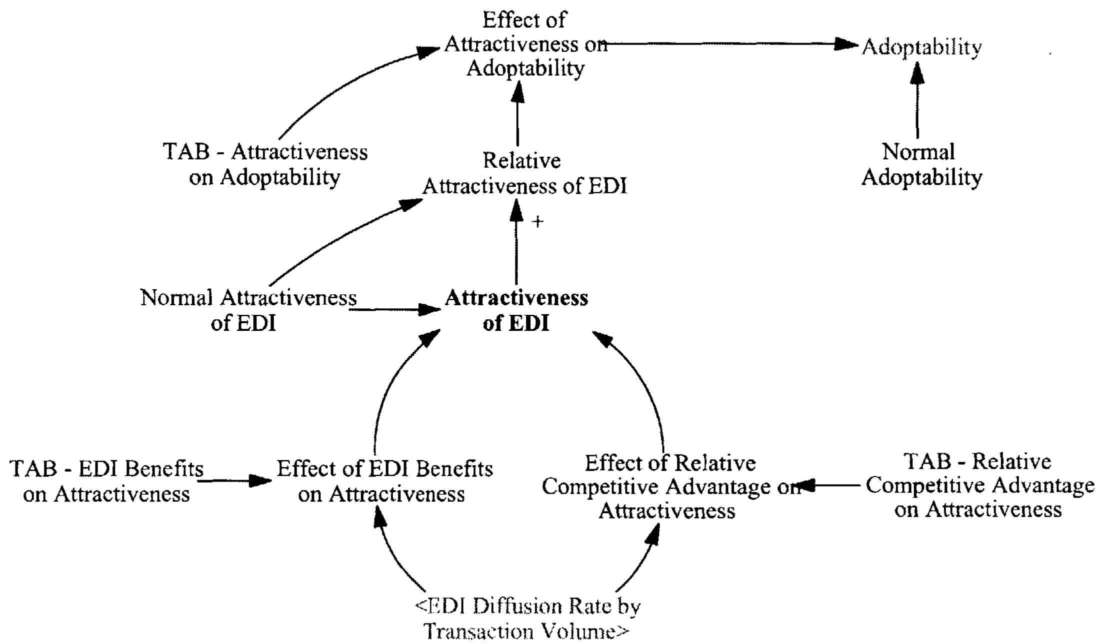


Figure 7-7 Structure of Adoptability Sector

(11) Adoptability = Normal Adoptability * Effect of Attractiveness of Adoptability

(12) Effect of Attractiveness on Adoptability = "TAB - Attractiveness on Adoptability"(Relative Attractiveness of EDI)

(13) Relative Attractiveness of EDI = Attractiveness of EDI / Normal Attractiveness of EDI

(14) Attractiveness of EDI = Normal Attractiveness of EDI * Effect of EDI Benefits on Attractiveness * Effect of Relative Competitive Advantage on Attractiveness

(15) Effect of EDI Benefits on Attractiveness = "TAB - EDI Benefits on Attractiveness" (EDI Diffusion Rate by Transaction Volume)

(16) Effect of Relative Competitive Advantage on Attractiveness = "TAB - Relative Competitive Advantage on Attractiveness" (EDI Diffusion Rate by Transaction Volume)

7.5 Model Validation

As explained in the section of 6.5.1, a system dynamics model should satisfy the structure validity and behavior validity. Given the fact that the model developed in this research for diffusion dynamics of EDI is adapted from the Bass model, which is a widely accepted model for the diffusion dynamics of new technology or product, the model can be regarded as passing the structure validity test. There are no significant structural changes in the model compared with the Bass model. Then, the next challenge is to ensure the behavior validity of the model, or model calibration to the historical data, which is explained in this section.

7.5.1 Parameter Estimation

In order to calibrate the model, exogenous parameters should be collected first. There are nine exogenous parameters to be estimated, and they are presented in Table 7-3.

Table 7-3 Exogenous Parameters to the Model for Diffusion Dynamics of EDI

Variable Name	Value	Unit	Descriptions and Source
Total Players	1000	Company	This is the approximate total number of carriers, shippers, and intermediaries, which can potentially impact the container shipping industry, ignoring smaller players.
Initial EDI Users	50	Company	Initial "EDI diffusion rate by users" is assumed to be 5% in the year of 1990.
Contact Rate	11	1 / Year	A rate that total users interact each other during a certain period, i.e., measured in company contacted per potential EDI users per time period, or [1/time]. It is estimated from the calibration process.
Effectiveness of Trading Partners' Demand	0.02	1 / Year	The fraction that potential EDI users become active EDI users due to the trading partners' demand. It is assumed to be 2% per year.

Variable Name	Value	Unit	Descriptions and Source
Normal Adoptability	0.015	Dimensionless	The fraction that contacts between potential EDI users and EDI users make potential EDI users become active EDI users. It is assumed to be around 1.5%.
Normal Attractiveness	1	Dimensionless	Reference level of attractiveness in 1990. It is set as unity for the simulation purpose.
Container Shipping Demand	10.4 ~ 17.9 million	TEU / Year	Drewry Shipping Consultants (1999)
Average Transactions per Container Shipping Demand	20	Transaction / TEU	It is assumed that on average twenty different transactions are required to transport a container. This is based on the number of EDI transaction sets to be used for container shipping (Sokol, 1995)
Average EDI Transactions per Users	485,145	Transaction / (Company * year)	This is the average EDI transactions per EDI users. It is estimated by from the calibration process.

7.5.2 Model Calibration and Simulation Results

After collecting the data for exogenous parameters, the model is calibrated to the real data in order to ensure the behavior validity. For the calibration purpose, nonlinear least squares estimation using Powell's (1969, 1972) optimization algorithm as implemented in Vensim® is used in this research. The EDI diffusion rate by users is set as the variable for objective function to be calibrated, and five variables are selected for constraints (Table 7-4). Three estimated nonlinear relationships for constraints from the calibration process are shown in Figure 7-8, Figure 7-9, and Figure 7-10.

The simulation results are also shown in the following (Figure 7-11 ~ Figure 7-15), and the summary statistics for the historical fit of the model to the real industry data are shown in Table 7-5.

Table 7-4 Objective Functions and Constraints for Calibration of the Model of EDI Diffusion

Variables for Objective Functions	Variables for Constraints
• EDI Diffusion Rate by Users	• Effect of Attractiveness on Adoptability • Effect of EDI Benefits on Attractiveness • Effect of Relative Competitive Advantage on Attractiveness • Contact Rate • Average EDI Transactions per EDI Users

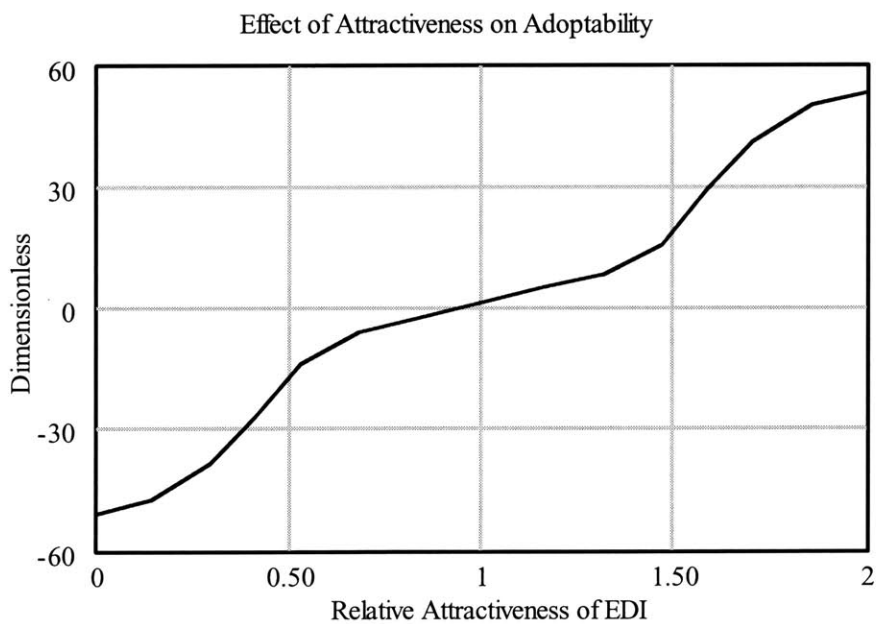


Figure 7-8 Effect of Attractiveness on Adoptability of EDI

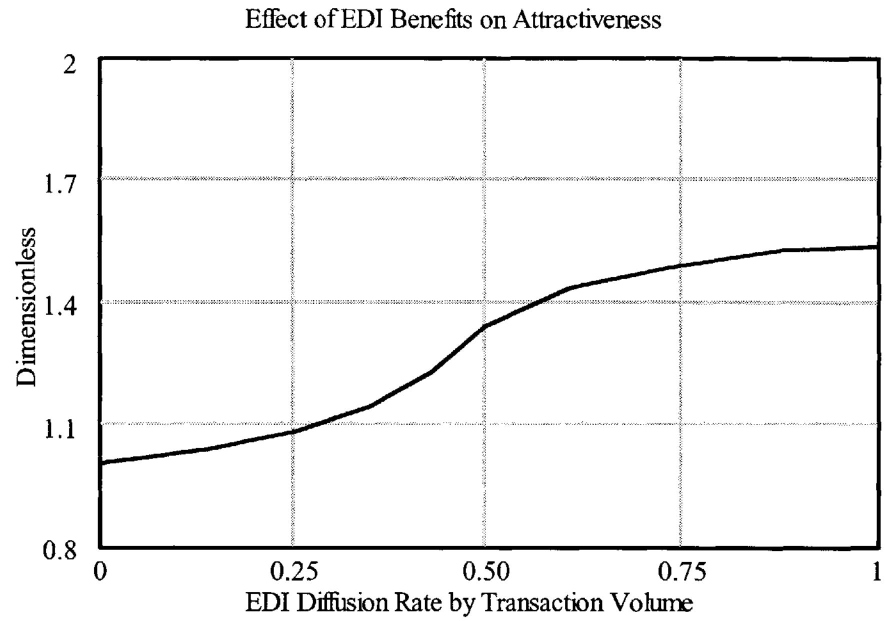


Figure 7-9 Effect of EDI Benefits on Attractiveness of EDI

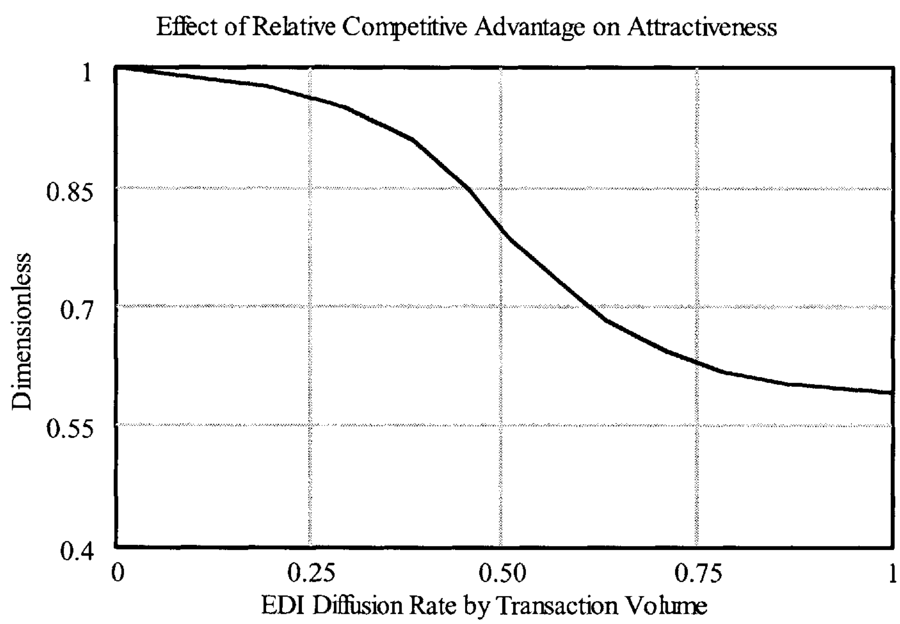


Figure 7-10 Effect of Relative Competitive Advantage on Attractiveness of EDI

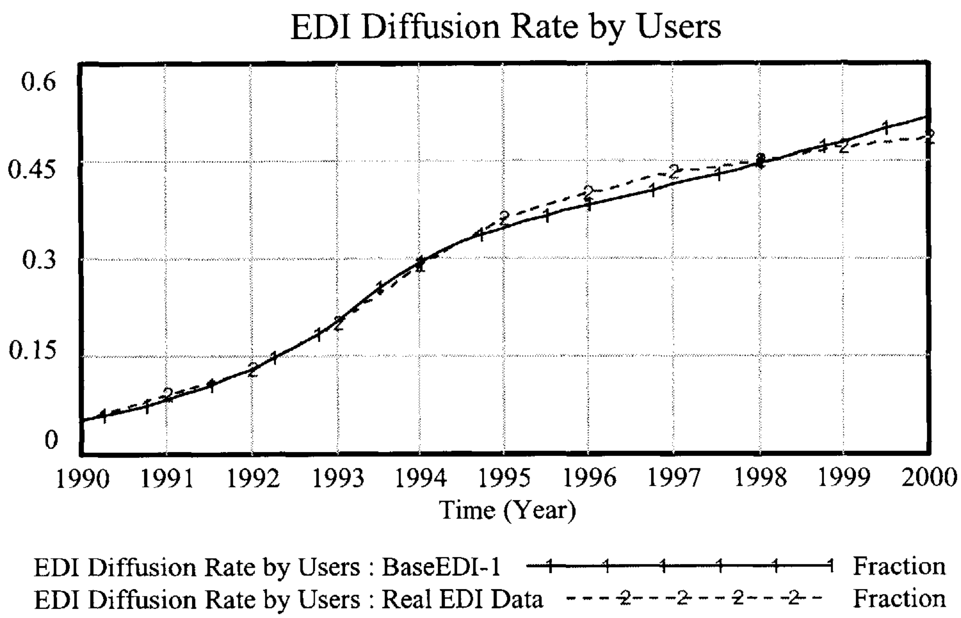


Figure 7-11 EDI Diffusion Rate by Users

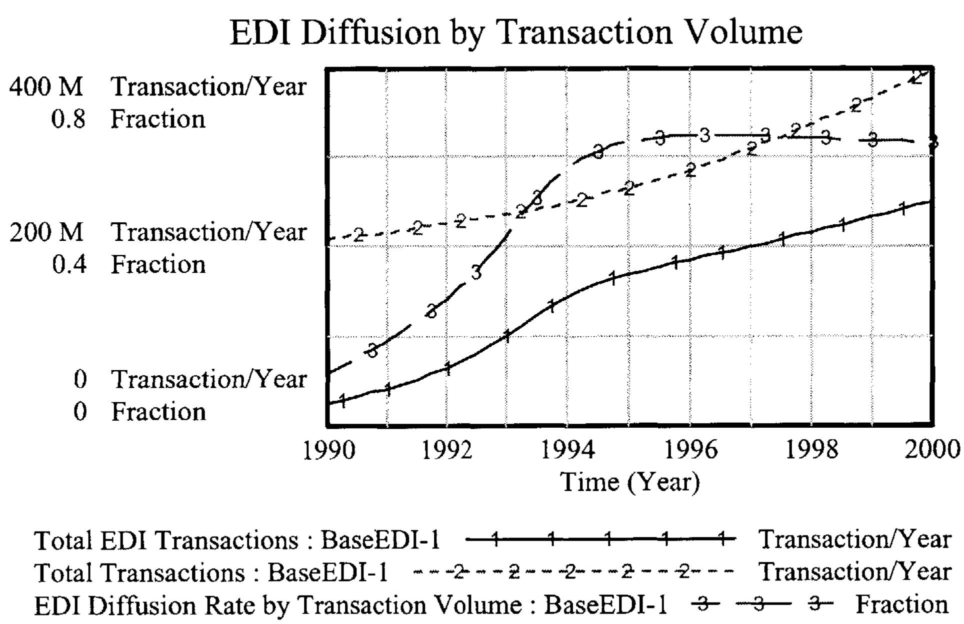


Figure 7-12 EDI Diffusion Rate by Transaction Volume

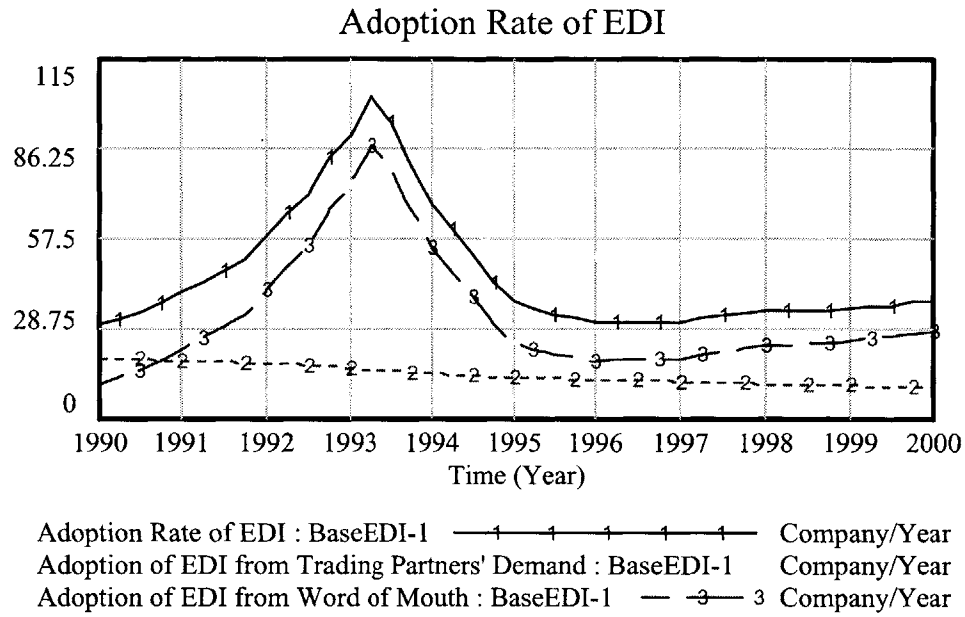


Figure 7-13 Adoption Rate of EDI

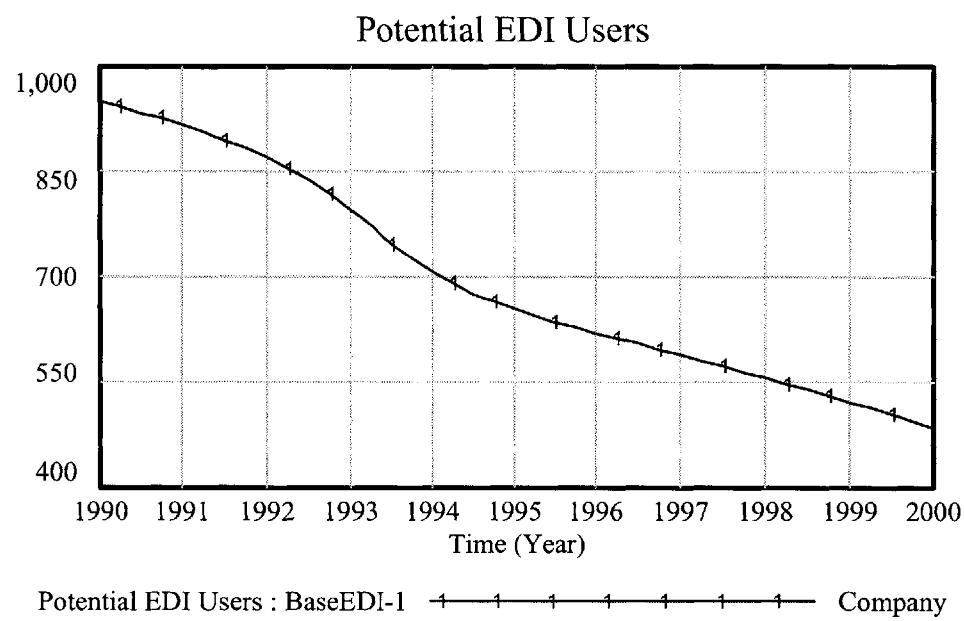


Figure 7-14 Potential EDI Users

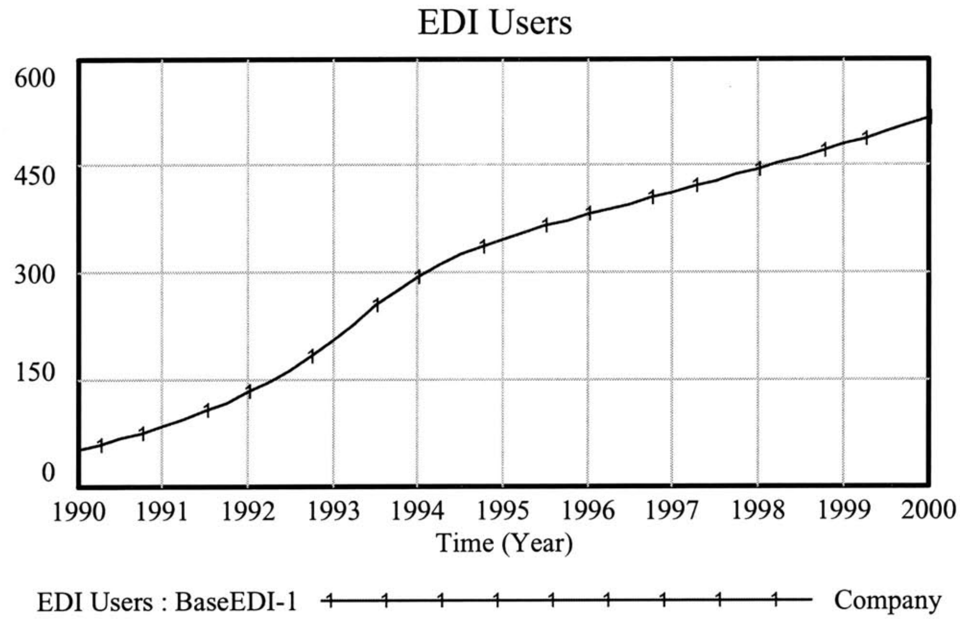


Figure 7-15 EDI Users

Table 7-5 Summary Statistics for the Model of EDI Diffusion

Variable Name	Data Points	R^2	MAPE	Theil's Inequality Statistics		
				Bias	Unequal Variation	Unequal Covariance
EDI Diffusion Rate by Users	11	0.993	3.0%	0.007	0.018	0.975

The simulation results confirm that the model tracks successfully the real data of EDI diffusion in the container shipping industry, measured by the EDI diffusion rate by users, which shows a S-shaped curve (Figure 7-11). The Mean Absolute Percent Error (MAPE) for the EDI diffusion rate by users is just 3%, indicating a close fit of the model to the actual behavior of EDI diffusion in the container shipping industry. Moreover, the low bias and variation components of the Theil's inequality statistics confirm that errors are unsystematic (Sterman, 1984, 2000).

Meanwhile, the EDI diffusion rate by transaction volume increased quickly from 1990 to 1995 and started to stagnate from then on (Figure 7-12). Corresponding to the S-shaped adoption of EDI by the 1990s, the adoption of EDI was faster by 1994 and then slower after that (Figure 7-13). Accordingly, the potential EDI users have been decreasing over time while the EDI users have been increasing in the 1990s with different growth rates (Figure 7-14, Figure 7-15).

7.5.3 Sensitivity Analysis

There are two parameters assumed in the model calibration – effectiveness of trading partners' demand and normal adoptability. In order to ensure the confidence of the model by testing the sensitivity of the system to these parameters, a batch of Monte-Carlo simulations is performed. The two parameters are assumed to have a uniform distribution around the values assumed, and the range is set to cover 25% of upper and lower of the value. The simulations are run with the parameters estimated from the calibration process.

Figure 7-16 and Figure 7-17 show the results of sensitivity simulations with 50% and 95% confidence bounds. Both the EDI diffusion rate by users and the EDI diffusion rate by transaction volume are generally stable under the change of the two parameters - effectiveness of trading partners' demand and normal adoptability – except the time between 1993 and 1995 when EDI is actively adopted among the container shipping industry. After the year of 1998 when the adoption rate of EDI started to be slow, the confidence bounds of the EDI diffusion rate by users and the EDI diffusion rate by transaction volume are narrow around the values in the base case.

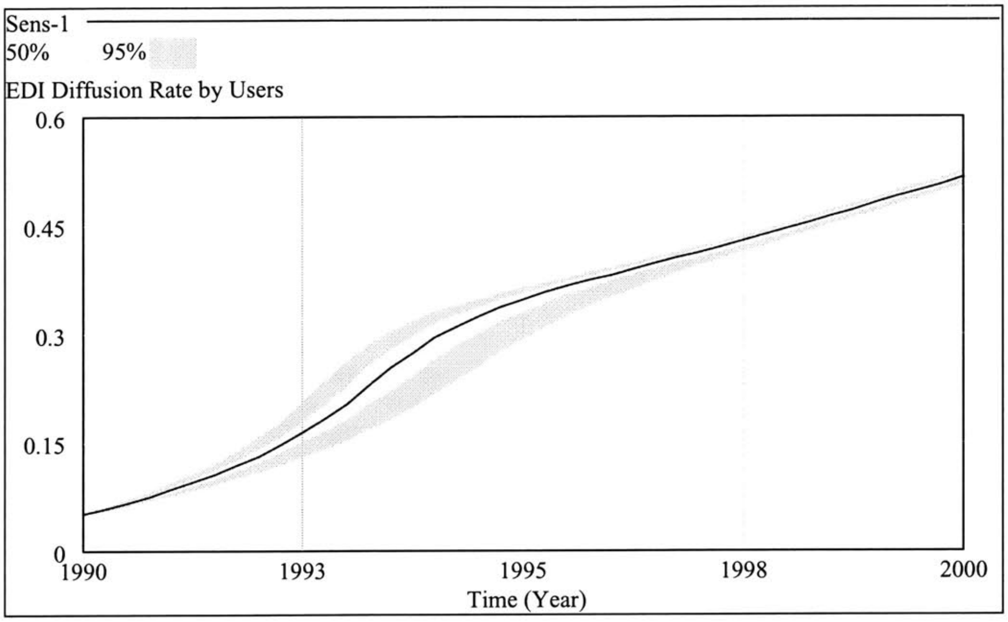


Figure 7-16 Sensitivity Analysis: EDI Diffusion Rate by Users

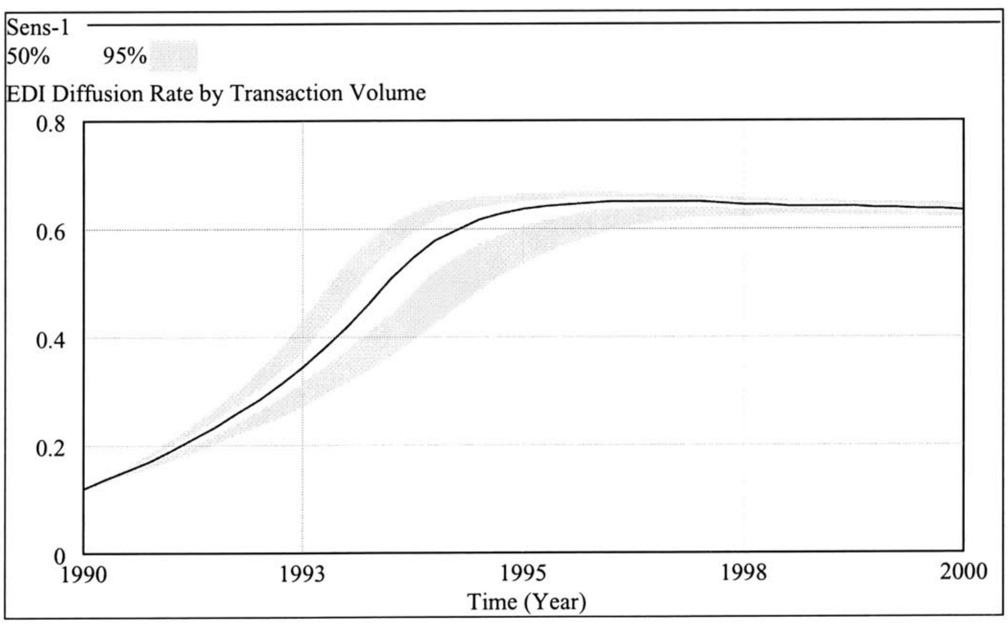


Figure 7-17 Sensitivity Analysis: EDI Diffusion Rate by Transaction Volume

7.6 Conclusions

This chapter has presented a system dynamics model for simulating the diffusion dynamics of EDI in the container shipping industry in the 1990s. The model is based on the Bass model, which is widely used for modeling the diffusion of new technology or product over time, ensuring the structure validity of the model. The calibration process confirms that the model tracks the diffusion of EDI in the container shipping industry quite well and is stable against the disturbance in the parameters assumed.

Chapter 8 Model for the Impact of e-Business on the Container Shipping Industry

8.1 Introduction

This chapter describes a study to analyze the potential impacts of e-business on the container shipping industry by developing a system dynamics model. The model is constructed by integrating the models explained in chapter 6 and chapter 7, supplementing them with the additional dynamics that simulate the potential interactions between the current strategic challenges of carriers and the promising e-business models.

The future base case, which models the future industry behaviors without considering any impact of e-business activities, is first presented in section 8.2. Next, the integrated model for analyzing the potential impacts of e-business on the container shipping industry is explained in section 8.3. Then, section 8.4 provides the major findings from the simulation of the integrated model. Finally, section 8.5 discusses the three findings on the commoditization of the logistics service offering, followed by the conclusions in section 8.6.

8.2 Analysis of the Future Base Case

A first step to test the potential impacts of e-business on the container shipping industry is to estimate the future base case. The future base case activates only the feedback loops that have controlled the traditional dynamics of supply-and-demand in the container shipping industry without considering any potential impact of the dynamics of LSO and e-business activities. This future base case will be used as a reference system to measure the potential impacts of e-business on the container shipping industry.

The model for the dynamics of supply-and-demand in the CSI as discussed in chapter 6 is extended to the year of 2020 to make the future base case. In order to extend the time frame of the simulation, several assumptions are made to drive the simulation. Table 8-1 shows the assumptions made for the future base case.

Table 8-1 Assumptions for the Future Base Case

Variables	Assumptions
GDP Growth Rate	Assuming the sine curve which follows the patterns of GDP growth rate from 1985 to 2000. The parameters of the sine curve of GDP growth are in the following: - Amplitude = 0.0082 - Period = 10.2 years - Baseline offset = 3.29 % See Figure **8-1** below for the graph of GDP growth rate assumed
GDP Sensitivity on Indicated Demand	In the 1990s, the fast growing trend of globalization must have exaggerated the container shipping demand . However, the globalization will be expected to be mature and slower over time so that the GDP sensitivity on indicated demand will become decreased. Therefore, the future GDP sensitivity on indicated demand is assumed to decrease by 5% of the current GDP sensitivity to reflect the slower globalization and the maturing trend of the container shipping volume.
Average Voyages per Year	It is assumed to be as same as in the 1990s – 6.8 voyages per year
Reference Utilization	It is assumed to be as same as in the recent years – 75%
Capacity Adjustment Time	It is assumed to be as same as in the recent years – 4 years
Effect of Economy of Scale on Cost	It is assumed that the effect of economy of scale on cost will be decreasing at decreasing rate because the benefit of economy of scale will be limited over time (Wijnolst, et al., 2000). See Figure **8-2**

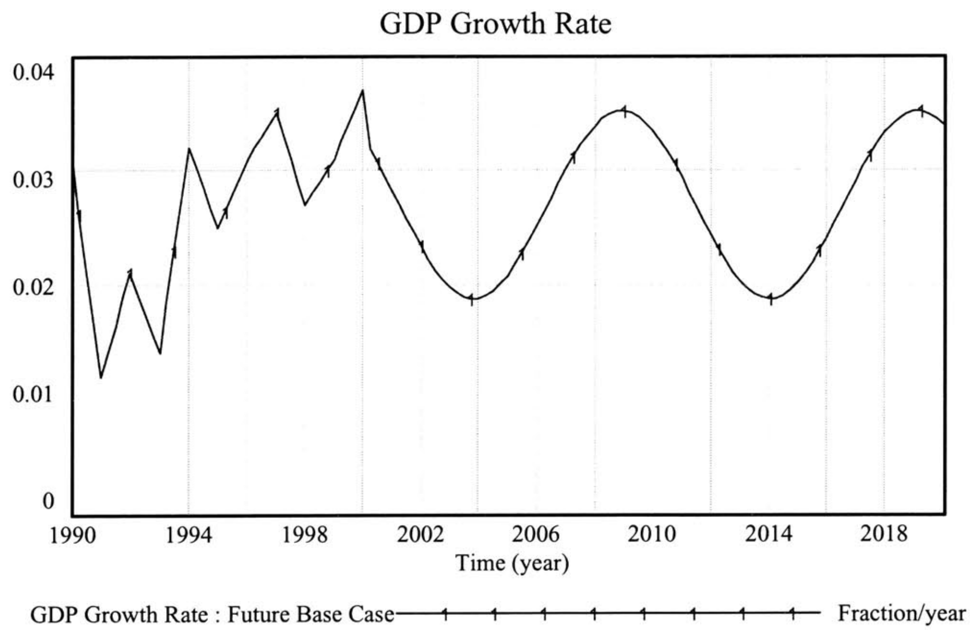


Figure 8-1 Assumed Growth Rate of GDP

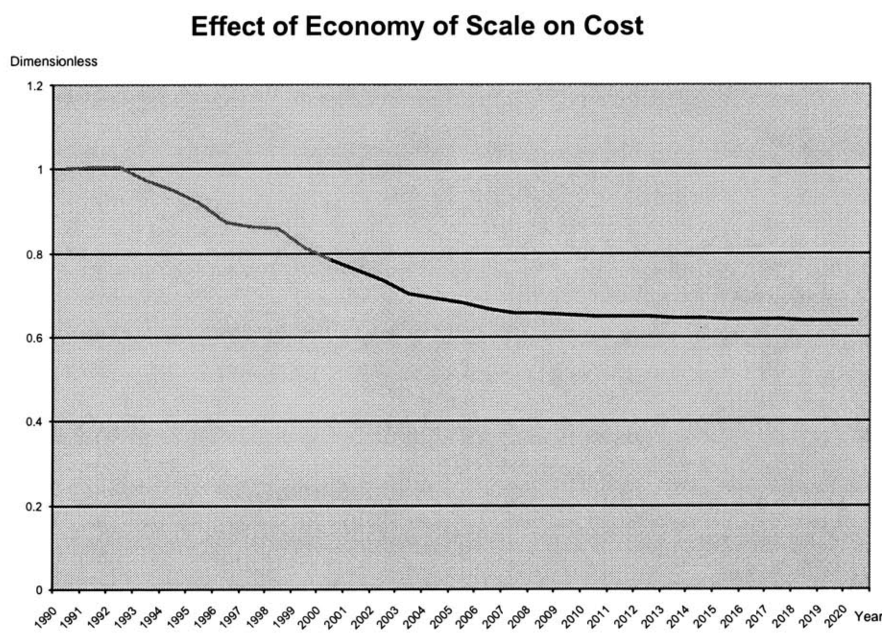


Figure 8-2 Effect of Economy of Scale on Cost Assumed

After setting the parameters assumed above, running the model for the dynamics of supply-and-demand presents the future base case in the container shipping industry. Below are the simulation results of the future base case, which covers the time period from the year of 1990 to the year of 2020 (Figure 8-3 ~ Figure 8-8). Real industry data in the 1990s are also drawn in dotted red line. The future base case provides several insights into the future dynamics of the container shipping industry given that the industry maintains the current practices of supply-and-demand of the container shipping service.

- Despite the decreased impact of GDP growth rate on the container shipping demand, the demand is expected to grow on average 9% per year.

- The containership capacity will also increase substantially over time. However, the orderbook of containerships will be more cyclical than in the 1990s.

- After being substantially depressed to lower than 60% by the end of 2002, the utilization is estimated to be slightly improving afterwards. However, the overall utilization will be trapped around 63%, which is 13% lower than the average utilization in the 1990s.

- When the utilization goes down, the freight rate will also be substantially eroded and then hardly improved. After maintaining around \$ 1,047 / TEU in the 2000s, the freight rate is expected to be stagnated around \$ 966 / TEU in the 2010s. The overall average freight rate is around \$ 1,007 / TEU, which is 29% lower than the average freight rate in the 1990s.

- In accordance with the lowered utilization and freight rate, the future profitability will be much lower and more cyclical than in the 1990s. The average profit margin of carriers from the year of 2000 to 2020 is expected to be around 3.9%, which is 35% lower than the average profitability in the 1990s

In summary, without any change in the current dynamics of supply-and-demand in the container shipping industry, the container shipping industry will be much more commoditized over time: the utilization, freight rate, and profitability of carriers will be substantially lowered and trapped in such a low level. Providing the container shipping service with low 60% of utilization and as low as $ 1,000 / TEU of freight rate, generating a profit margin of around 3.9%, is hardly sustainable and differentiable. In addition, the cyclicality of the containership orderbook and profitability of carriers will become more intense; hence, maintaining the sustainable operation of the container shipping service will be much harder than ever. Carriers should implement new strategies to avoid this difficult business environment.

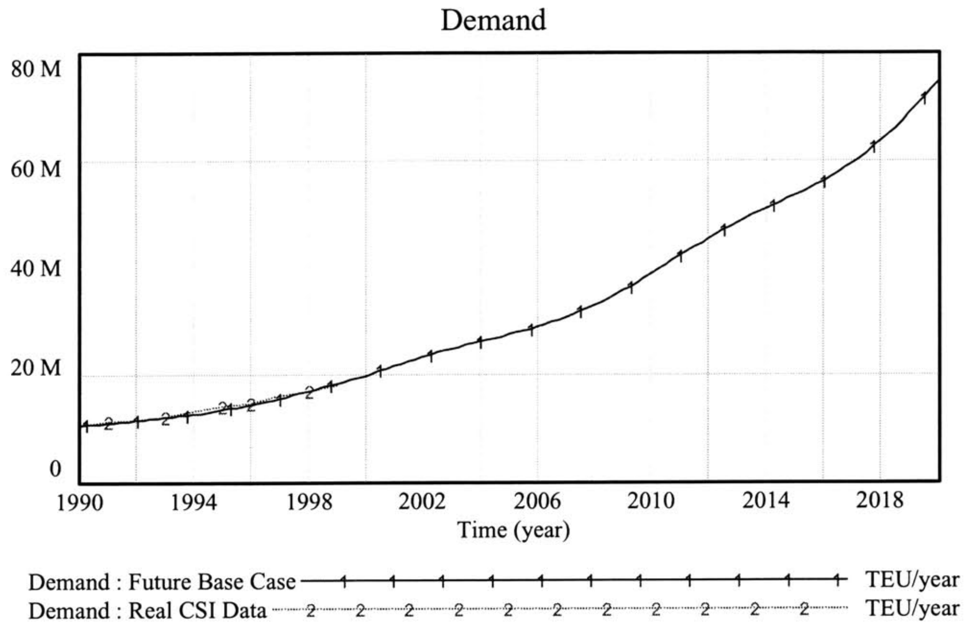


Figure 8-3 The Future Base Case - "Demand"

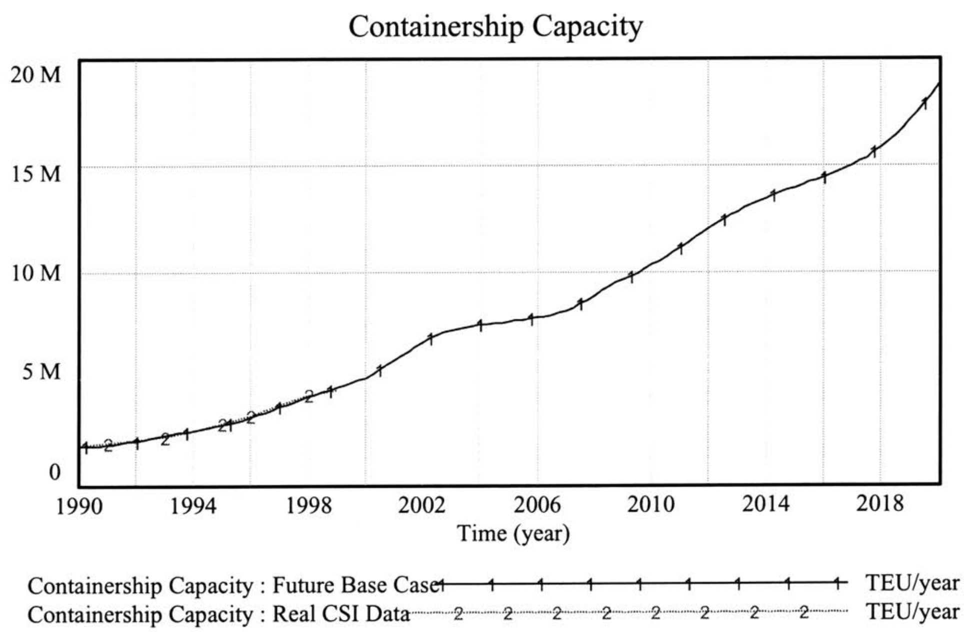


Figure 8-4 The Future Base Case - "Containership Capacity"

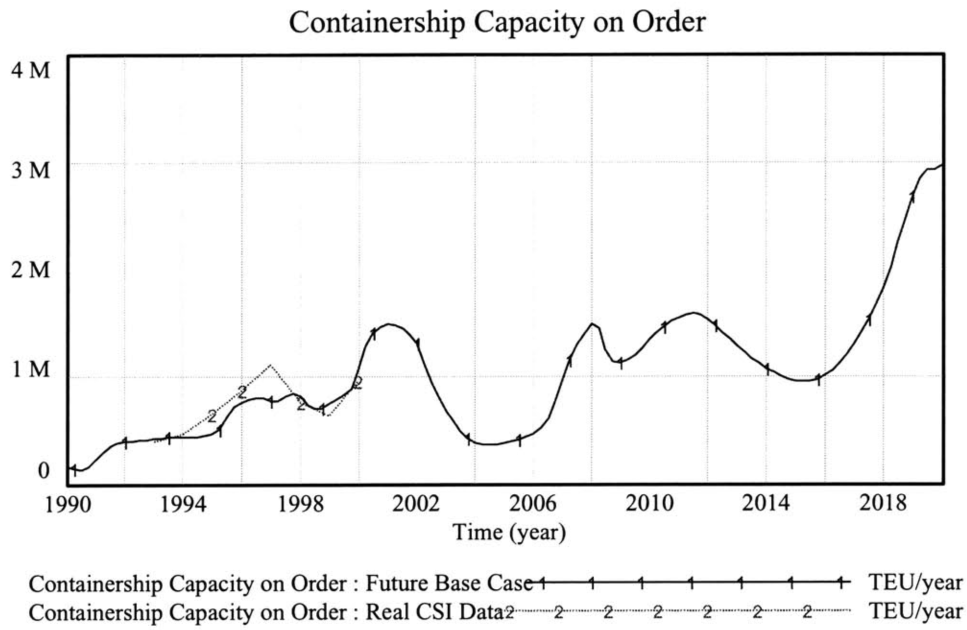


Figure 8-5 The Future Base Case - "Containership Capacity on Order"

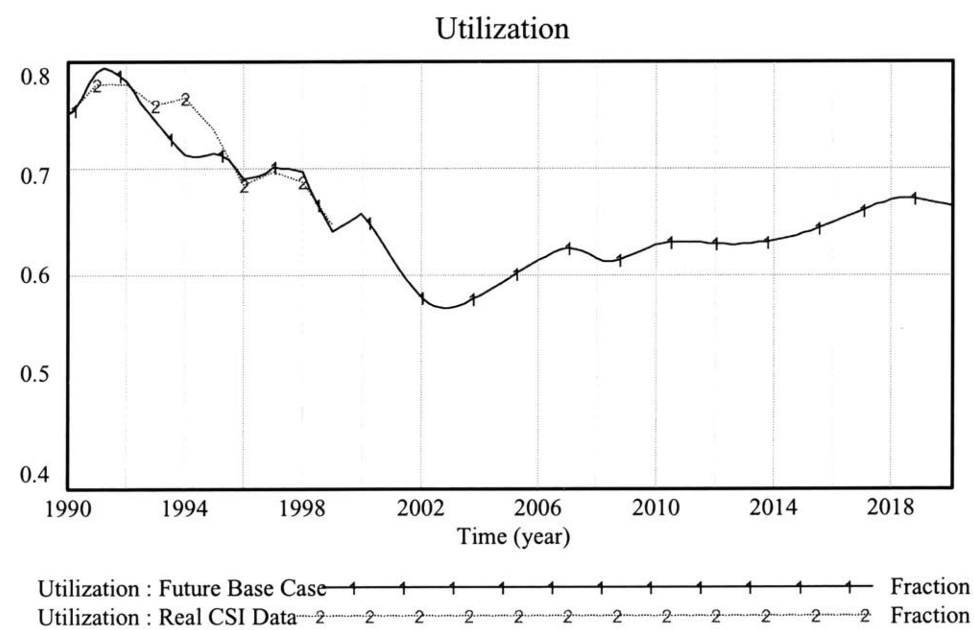


Figure 8-6 The Future Base Case - "Utilization"

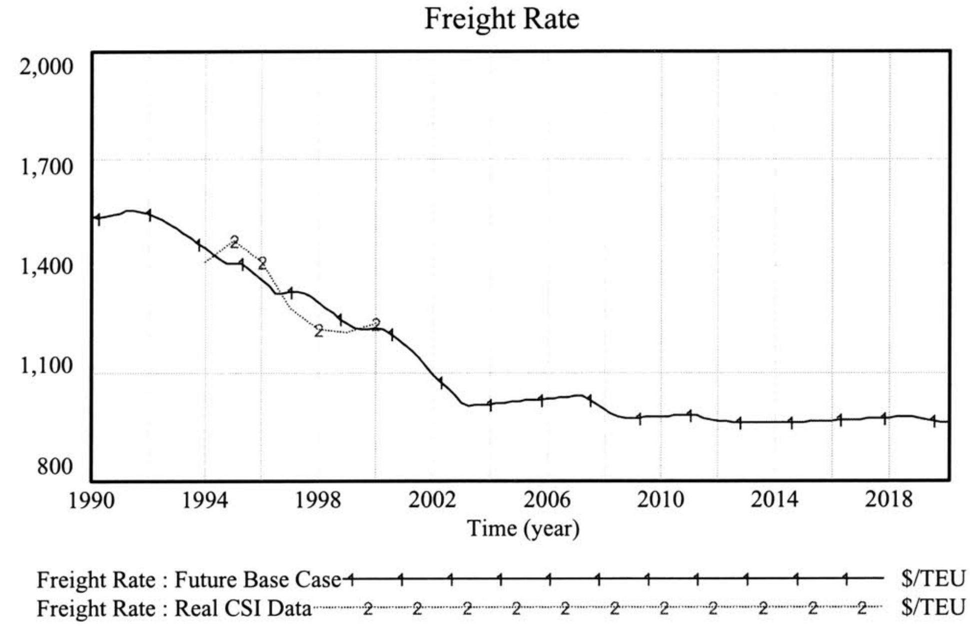


Figure 8-7 The Future Base Case - "Freight Rate"

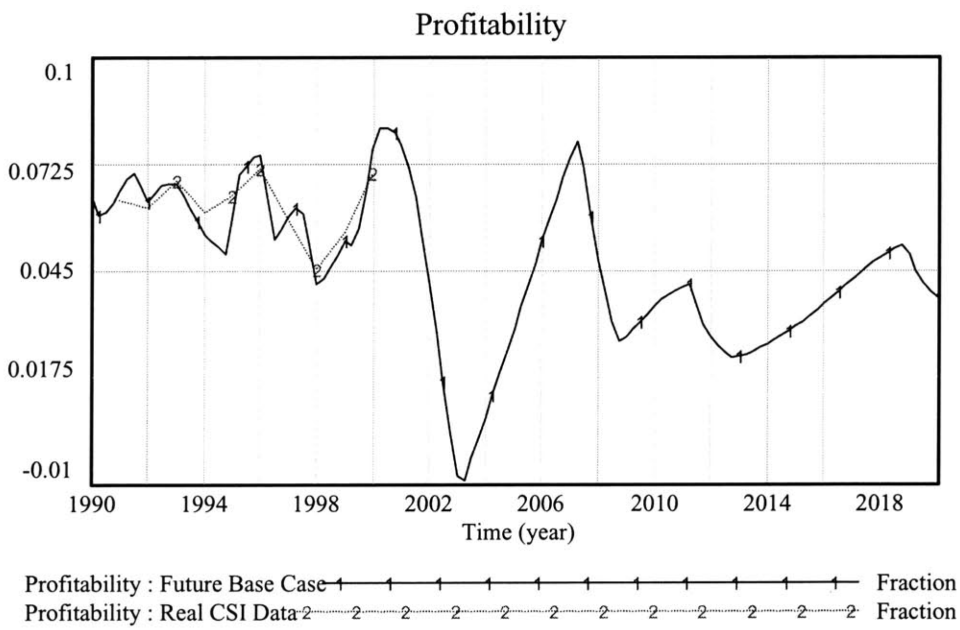


Figure 8-8 The Future Base Case - "Profitability"

8.3 Modeling the Impacts of e-Business on the Container Shipping Industry – The Integrated Model

This section describes the integrated model that is developed for analyzing the impacts of e-business on the container shipping industry. After reviewing the general structures of the integrated model in section 8.3.1, section 8.3.2 and section 8.3.3 explain the causal loop diagrams of the integrated model and the detailed model structures, respectively. Next, section 8.3.4 presents the estimated values of the exogenous parameters used in the integrated model, followed by the simulation results in section 8.3.5.

8.3.1 Overview of the Integrated Model for the Impacts of e-Business

In chapter 2, three major strategic challenges of carriers – logistics service offering, control of asset management costs, and control of transaction costs – were analyzed based on the current competitive drivers in the container shipping industry. In addition, two promising e-business models – CTP in alliance with carrier-oriented portal and e-PSP – were identified in chapter 5 by evaluating the success potential of the e-business models with three different frameworks.

These strategic challenges of carriers and the promising e-business models will interact with each other and the interactions will have multi-facets (see Figure 8-9). For example, the CTPs will interact with the trend of logistics service offerings because the CTPs provide the internet-based platforms that help carriers and shippers manage their logistics needs more efficiently. Moreover, the CTPs can aid carriers in reducing the transaction costs by lowering market research costs, documenting costs, and customer support costs, etc. In addition, e-PSPs could interact with the trend of controlling the asset management costs.

Among the potential interactions between the strategic challenges of carriers and the e-business models, the interactions involved with the CTPs are expected to be more immediate and substantial because the CTPs are the most promising e-business model.

Furthermore, developing the logistics service offering is one of the most urgent tasks that carriers should perform in order to be successful in the environment of ever eroding profitability of the container shipping service. Accordingly, the potential impacts of e-business on the container shipping industry could be dominated by the potential interactions between the dynamics of logistics service offerings and the CTPs. Therefore, the model for analyzing the impacts of e-business on the container shipping industry in this research will be focused on the interactions between the dynamics of logistics service offering and the role of the CTPs in the container shipping industry.

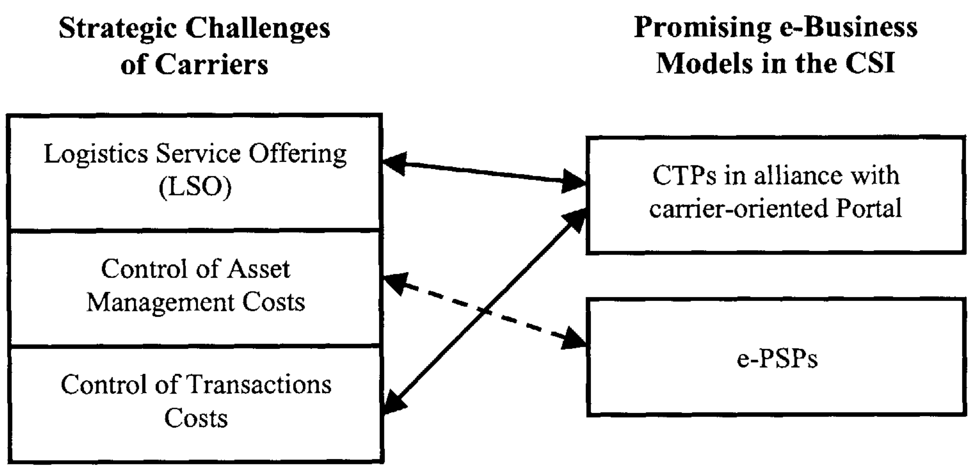


Figure 8-9 Interactions between Strategic Challenges of Carriers and e-Business Models

Based on the analysis above, a proposed system dynamics model for the impacts of e-business on the container shipping industry is composed of three sub-sectors (see Figure 8-10): a sector for the dynamics of supply-and-demand in the CSI, a sector for the dynamics of logistics service offering, and a sector for the diffusion of e-business in the container shipping industry. The first sector is adapted from the model discussed in chapter 6 while the third sector is updated from the model of EDI diffusion in the container shipping industry, which is described in chapter 7. The second sector will be explained in this chapter. All sub-sectors are integrated in the end to test the impact of e-business on the container shipping industry.

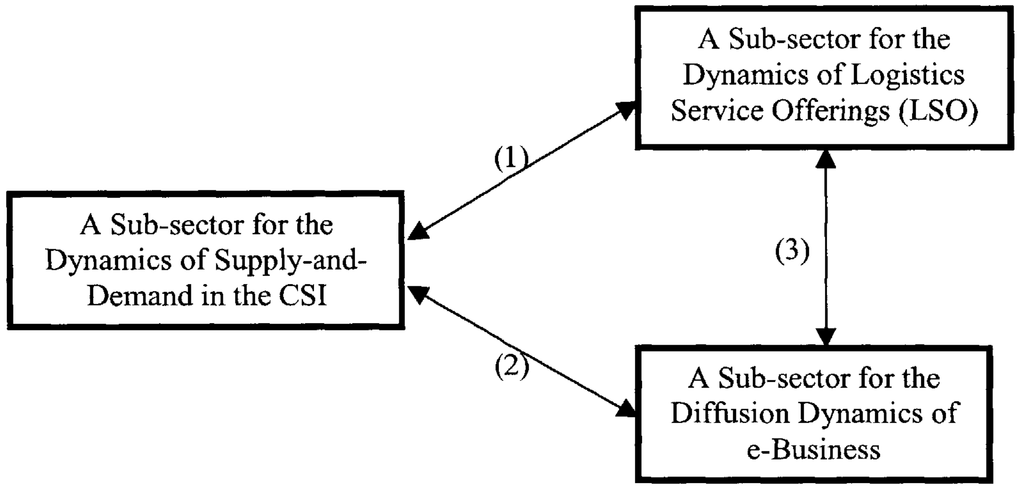


Figure 8-10 Structure of the Proposed System Dynamics Model for the Impacts of e-Business on the Container Shipping Industry

The process of integrating the sub-sectors are performed gradually – the sector for the dynamics of supply-and-demand in the CSI is extended to the future without considering any impact of the dynamics of LSO and e-business, providing the future base case as a reference system for testing the additional impacts; the sector for the dynamics of logistics service offering is then added onto the first sector to analyze the potential impacts of logistics service offering in the container shipping industry; the sector for the diffusion dynamics of e-business is further imposed on the model to delineate the impacts of e-business on the container shipping industry in relation to the dynamics of logistics service offering; and finally all subsectors are fully integrated to test the impacts of e-business on the CSI.

The procedure of the model building is based on the assumption that carriers might have three strategies to improve the logistics service offering: increasing the LSO capability by adding more logistics salesforce without adopting e-business, or "vertical integration strategy"; increasing the LSO capability by actively adopting e-business activities, or "virtual integration strategy"; and combining the two strategies at a time, or "mixed integration strategy." Among the three sub-sectors, the second sub-sector that simulates the dynamics of logistics service offering is driven by the vertical integration strategy and the third sub-sector representing the diffusion dynamics of e-business is used for testing the virtual integration strategy. The fully integrated model combining the three sub-sectors all together is used for analyzing the mixed integration strategy.

The purpose of the integrated model is not to predict the future relating to the logistics service offering and the e-business activities; Rather, through the model building process, it is to decompose the complex potential dynamics of the interactions between the LSO and e-business activities into several manageable sectors, understand the dynamic behaviors of the system over time, and gain the insights into how to cope with the strategic challenges posed by the logistics service and the e-business activities.

8.3.2 Causal Loop Diagrams for the Integrated Model

As Figure 8-10 represents, the causal loop diagram, on which the integrated model for testing the impacts of e-business on the CSI is based, should be composed of three sub-diagrams – the causal relationships for the dynamics of supply-and-demand in the CSI, those for the dynamics of logistics service offering, and those for the diffusion dynamics of e-business.

The first causal relationships for the integrated model are for the dynamics of supply-and-demand in the container shipping industry (see Figure 8-11). Two balancing loops and one reinforcing loop are identified to connect the supply and demand of container shipping service through the freight rate, utilization, and cost variables. The detailed discussions on the role of each causal loop are already presented in section 6.3.

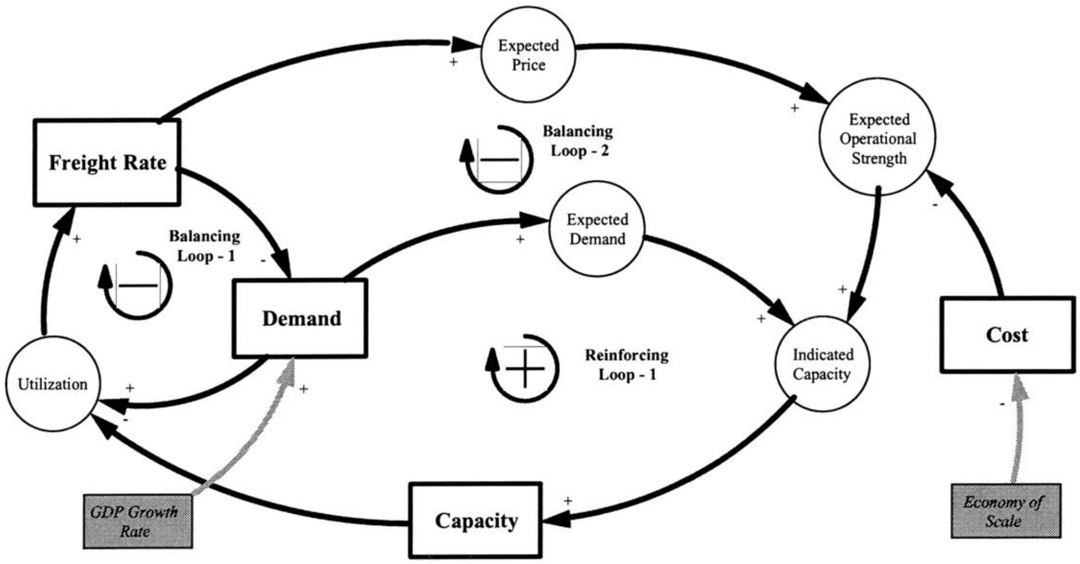


Figure 8-11 Causal Loop Diagram for the Dynamics of Supply-and-Demand in the Container Shipping Industry

The second component of causal relationships in the integrated model is for the dynamics of logistics service offering in the container shipping industry (see Figure 8-12 and Table 8-2). The causal loops for the LSO dynamics are constructed by focusing on the factors that might affect the level of carriers' LSO capability and their interactions with carriers' profitability. The diagram is an integral part to explain the "vertical integration strategy" of carriers, in which carriers develop their LSO capability by hiring additional salesforce. There are three major parts in this causal loop diagram: The first part represents how carriers hire salesforce to develop the LSO capability depending on the level of carriers' profitability. The second part simulates the dynamics of carriers' market share of logistics service, depending on the carriers' LSO capability and the level of carriers' commission for the logistics service. The carriers' market share of logistics service and the carriers' commission level determine the carriers' revenue from the logistics service. The third part is to consider the competition between intermediaries, who have been the major logistics service providers to shippers, and carriers, who attempt to offer the logistics service to shippers by improving their LSO capability. Intermediaries are assumed to change their LSO commission level to compete against the improving carriers' LSO capability in the model.

In total, twelve feedback loops are expected to govern the dynamics of LSO in the container shipping industry. The detailed explanation of the causal relationships for the LSO dynamics can be found in the Appendix.

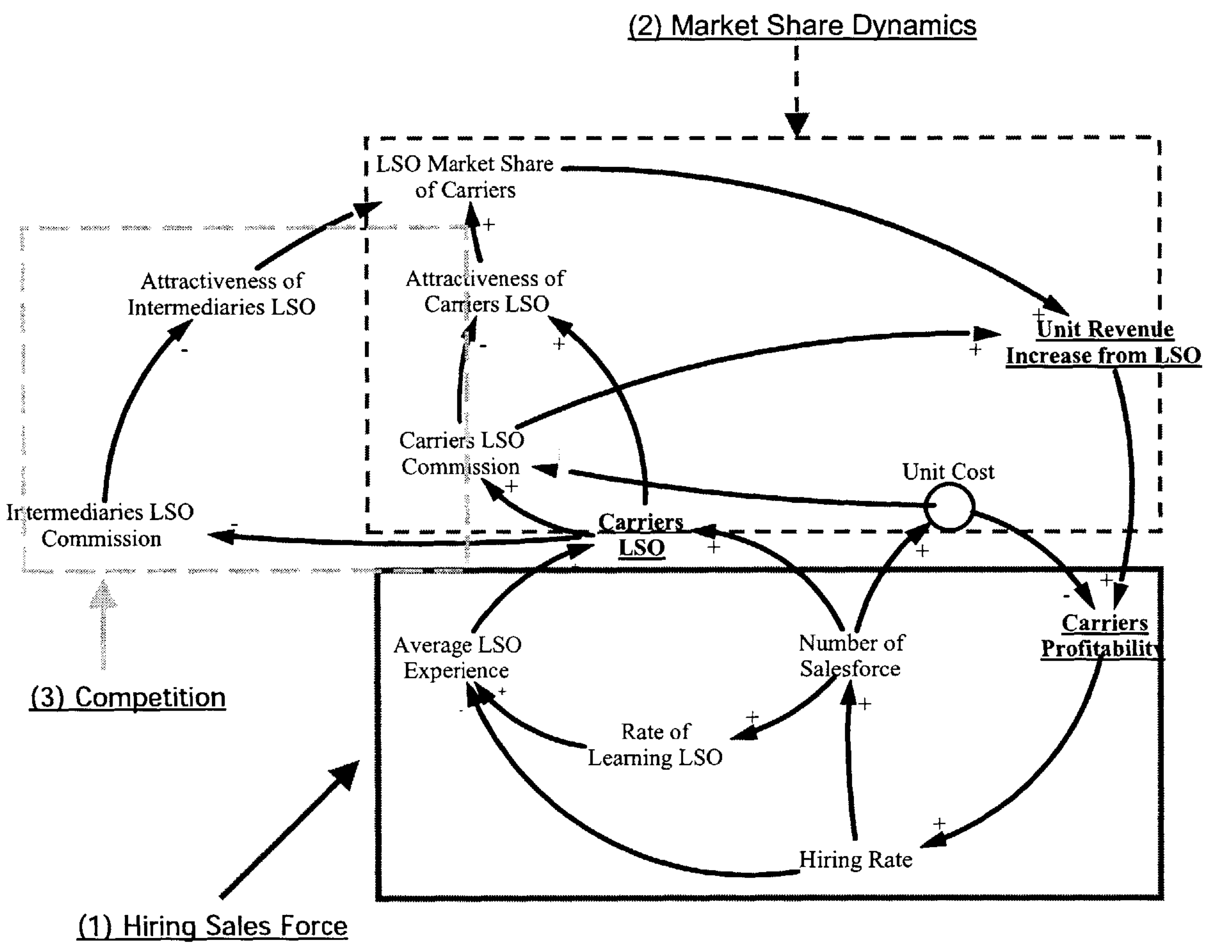


Figure 8-12 Causal Loop Diagram for the Dynamics of Logistics Service Offering

Table 8-2 List of Variables in the Causal Loop Diagram for the LSO Dynamics

Key Variables	Definition	Dimension	State Variable
Carriers LSO	The level of carriers' capability of providing logistics service measured in years of LSO experience	Year	
Average LSO Experience	The average experience of salesforce of providing LSO service	Year / People	Yes
Number of Salesforce	The number of salesforce of carriers in the container shipping industry	People	Yes
Carriers LSO Commission	The money that carriers charge per TEU for their LSO service	$ / TEU	Yes
Intermediaries LSO Commission	The money that intermediaries charge per TEU for their LSO service	$ / TEU	Yes
Rate of Learning LSO	The average rate at which salesforce gains the experience measured by "years" per year; i.e., this is the average rate of learning by the salesforce.	(Year/People)/Year	
Hiring Rate	The number of salesforce per year that carriers hire	People / year	
Carriers Profitability	The total operating margin per TEU divided by total revenue per TEU	Dimensionless	
Unit Revenue Increase from LSO	Carriers' annual additional revenue stream from LSO service, calculated by "Carriers LSO Commission" times "LSO Market Share of Carriers"	$ / TEU	
Unit Cost	The total cost of shipping a container and providing LSO, measured by dollar per TEU	$ / TEU	
LSO Market Share of Carriers	The carriers' market share in the LSO market	Dimensionless	
Attractiveness of Carriers LSO	The extent that the carriers' LSO service is attractive to shippers	Dimensionless	
Attractiveness of Intermediaries LSO	The extent that the intermediaries' LSO service is attractive to shippers	Dimensionless	

The last component of causal loop diagrams in the integrated model is to simulate the potential diffusion dynamics of e-business in the container shipping industry (see Figure 8-13 and Table 8-3). An important assumption with the causal relationships for the e-business diffusion in the integrated model is that the potential diffusion dynamics of e-business in the container shipping industry is similar to the historical diffusion dynamics of EDI in the container shipping industry. In other words, the diffusion rate of e-business will show an S-shaped curve due to the interactions of three feedback loops, which were found in the diffusion dynamics of EDI in the container shipping industry.

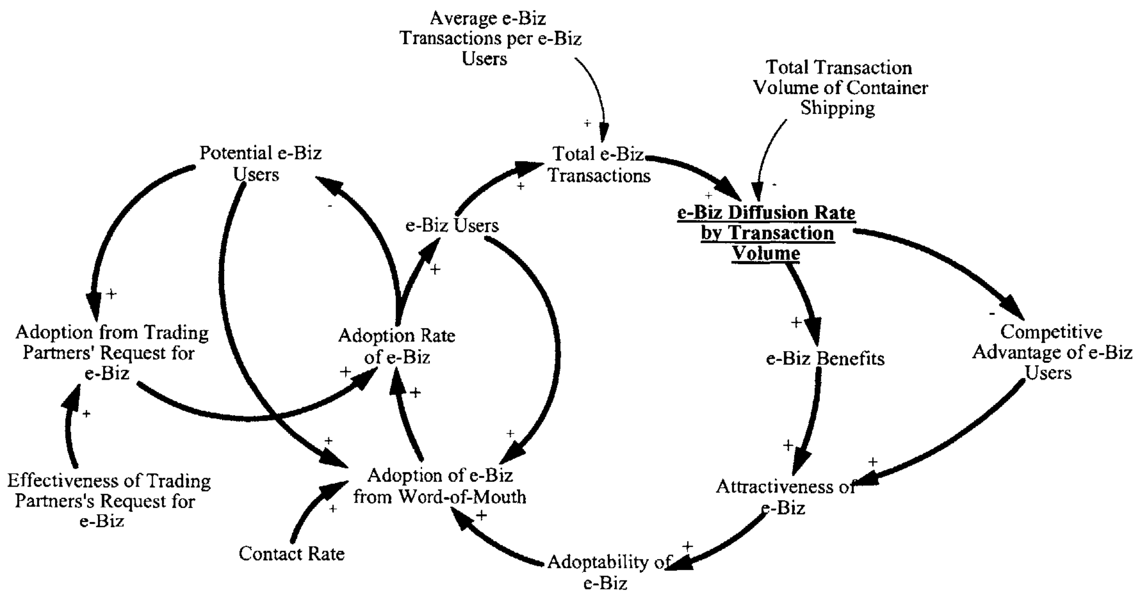


Figure 8-13 Causal Loop Diagram for the Potential Diffusion Dynamics of e-Business in the Container Shipping Industry

The reasoning behind this assumption is that EDI and e-business share the common characteristics. Both EDI and e-business – particularly the CTP model, which is expected to be most successful in the container shipping industry – have the characteristic of network externality, which is the major cause of S-shaped diffusion dynamics. In addition, although the extent of benefits might be different, the benefits of EDI and e-business are very similar to each other. For example, because both technologies provide tools for efficient information management, they help the container shipping industry reduce communication cost, reduce clerical errors, and improve productivity.

Therefore, the causal loop diagram for the potential diffusion dynamics of e-business is adapted from the causal loop diagram for the EDI diffusion dynamics. Comparing the causal loop diagram for the EDI diffusion dynamics as shown in Figure 7-2, the word of "EDI" is replaced by the word of "e-Biz" in Figure 8-13. The diagram is a crucial part for analyzing the "virtual integration strategy" of carriers, in which carriers develop their LSO capability by actively adopting e-business.

Three feedback loops are identified in Figure 8-13: balancing "trading partners' request" feedback loop, reinforcing "e-Business benefits" feedback loop, and balancing "competitive advantage" feedback loop. These feedbacks are equivalent to the balancing "trading partners' request" feedback loop, reinforcing "EDI benefits" feedback, and balancing "competitive advantage" feedback loop, respectively, as explained in section 7.3.

Combining the three sub-sectors, the causal loop diagram for the integrated model can be developed as shown in Figure 8-14. The three dynamics are interconnected each other. The e-business diffusion dynamics and the dynamics of supply-and-demand are interconnected by the demand; the LSO dynamics and the dynamics of supply-and-demand are integrated with the carriers' profitability; and finally the diffusion rate of e-business in the container shipping industry affects the rate of learning LSO and the unit cost of carriers. Certain portions of the connections in the causal loop diagram are activated or inactivated appropriately in analyzing the three different strategies of developing the LSO – the vertical, virtual, and mixed integration strategies.

Table 8-3 List of Variables in the Causal Loop Diagram for the Diffusion Dynamics of e-Business

Key Variables	Definition	Dimension	State Variable
Potential e-Biz Users	Potential number of e-business users in the container shipping industry	Company	Yes
e-Biz Users	The number of active e-business users in the container shipping industry	Company	Yes
Adoption Rate of e-Biz	The number of companies that adopt e-business per year	Company / year	
Adoption from Word-of-Mouth	The number of companies that adopt e-business per year by word-of-mouth process	Company / year	
Contact Rate	A rate that total players interact each other per year i.e., measured in company contacted per player per time year	1 / year	
Adoptability of e-Biz	A fraction that contacts between potential e-business users and e-business users make potential e-business users become active e-business users.	Dimensionless	
Attractiveness of e-Biz	The extent that e-business is attractive to the potential e-business users	Dimensionless	
Competitive Advantage of e-Biz Users	The extent of competitive advantage of e-business as a function of "e-Business Diffusion Rate by Transaction Volume"	Dimensionless	
e-Biz Diffusion Rate by Transaction Volume	A fraction that business transactions are executed by e-business	Dimensionless	

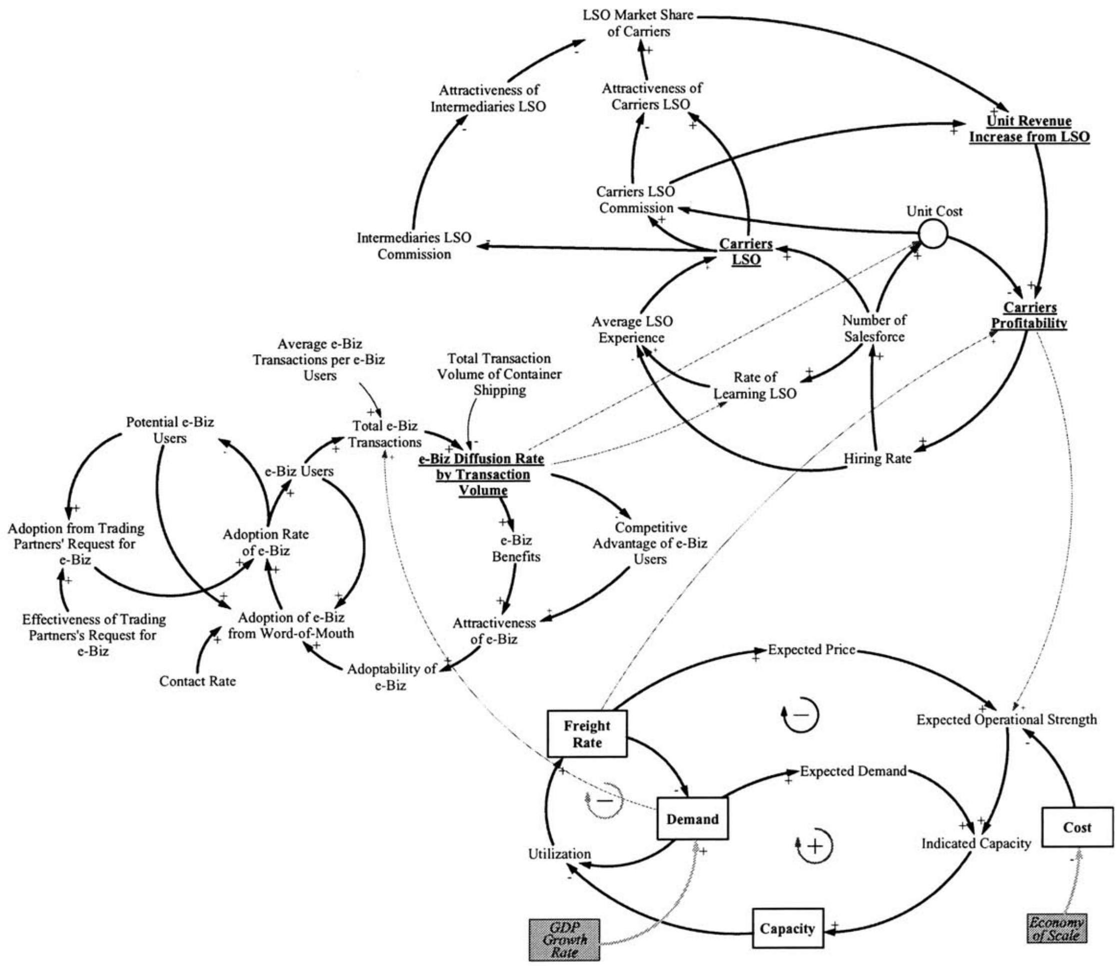


Figure 8-14 Causal Loop Diagram for the Integrated Model

8.3.3 Model Structure

Based on the causal loop diagram for understanding the impacts of e-business on the container shipping industry, the integrated model is developed. The relationships of (1), (2), and (3) in Figure 8-10 are modeled. It is assumed in the model that the LSO dynamics and the diffusion dynamics of e-business start to impact the container shipping industry from the year of 2001.

One thing explicitly excluded in the integrated model is the financial strength of intermediaries, which can impact the development of intermediaries' LSO capability and their LSO commission level. Since the purpose of the integrated model is to simulate and understand the impacts of the LSO dynamics and e-business on carriers' overall performance from the carriers' perspective, the development of intermediaries' LSO capability is exogenously input without considering the financial conditions of intermediaries.

For the presentation purpose, the integrated model is decomposed into twelve sectors: Four of them – the demand, freight rate, capacity, and cost sectors – come from the dynamics of supply-and-demand in the container shipping industry. Among the remaining eight sectors, six sectors – carriers LSO sector, intermediaries LSO sector, salesforce sector, market share sector, LSO commission sector, and LSO revenue sector – simulate the dynamics of developing the LSO. Finally, the remaining two sectors – e-business diffusion sector and adoptability sector – represent the potential diffusion dynamics of e-business in the container shipping industry. Section 6.4 explains the four sectors related to the dynamics of supply-and-demand in the container shipping industry while the Appendix presents the detailed descriptions of the remaining eight sectors.

8.3.4 Estimation of the Exogenous Parameters

To make the integrated model work, it is necessary to estimate the exogenous parameters that quantify the relationships among the variable. Four types of exogenous parameters for the LSO dynamics – exogenous input variables, reference points for decision-making, information delay time, and nonlinear relationships – are collected and used for the simulation run. In addition, several exogenous input variables and nonlinear relationships for the diffusion dynamics of e-business are also estimated for the simulation.

Unlike exogenous parameters of the model for the dynamics of supply-and-demand in the CSI and of the model for the diffusion dynamics of EDI in the CSI, those of the integrated model are in general hard to acquire because the LSO activities and the e-business diffusion in the container shipping industry are newly started and there have been very few industry resources to follow up those dynamics in the CSI. Despite this difficulty, the data are collected as much as possible from the industry resources and interviews with industry veterans, and the best judgment for each variable is used in the model when the data for the variables are not available at all. In order to supplement the uncertainty from the exogenous variables assumed, extensive sensitivity analyses are performed at the simulation stage. The exogenous parameters estimated to simulate the integrated model are explained in the following.

Table 8-4 presents the exogenous variables for the LSO dynamics, which set the initial condition of the model and draw the model boundary. All initial variables are set on the year of 2001, when the LSO dynamics are assumed to impact the container shipping industry. In addition, Table 8-5 explains the values of the reference points for the decision-making in the LSO dynamics, and the data for the information delay time in the LSO dynamics, which are needed for processing the managerial information, are shown in Table 8-6.

Table 8-4 Exogenous Input Variables for the LSO Dynamics

Variable Name	Value	Unit	Descriptions and Source
Initial Carriers LSO	20,000	Years	Initial total experience of LSO of carriers. It is estimated from [Initial Salesforce] times [Initial Average Experience of LSO], where • [Initial Salesforce] = 20,000 • [Initial Average Experience of LSO] = 1 year per salesforce Look at the descriptions of the initial salesforce and the initial average experience of LSO for sources
Initial Intermediaries LSO	200,000	Years	Initial total experience of LSO of intermediaries. It could be estimated from [Salesforce per Intermediary] x [Number of Intermediaries] x [Salesforce's Average Experience of LSO], such that: • [Salesforce per Intermediary] = 50 • [Number of Intermediaries] = 800 (because 4,000 OTI (from FMC, 2001) x 20% (only considering top 20%)), and • [Salesforce's Average Experience of LSO] = 5 years (Considering rapid outsourcing of logistics function in the 1990s). THEREFORE ==> 200,000 Year
Initial Salesforce	20,000	People	Assuming 100 container carriers with average 200 sales persons per carriers in 2001. Sources: Peter Keller from NYK North America said he had 60 - 80 salesforce in the US (2/22/02 Interview), and assuming that NYK has as same as salesforce in other regions. In order to make the salesforce unchanged until the year of 2000 (i.e., the LSO dynamics start to impact from the year of 2001), the initial salesforce is set in the model as [Average Hiring Rate] x [Time To Quit Or Retire Salesforce], which guarantees the equilibrium condition.
Average Hiring Rate	2,000	People / Year	Average hiring rate of carriers in the 1990s. It is estimated from [Initial Salesforce] / [Time To Quit Or Retire Salesforce], where [Initial Salesforce] = 20,000 people, and [Time To Quit Or Retire Salesforce] = 10 years.
Time to Quit or Retire Salesforce	10	Years	Average time that a salesman serves at the carriers. It is assumed to be around 10 years.

Variable Name	Value	Unit	Descriptions and Source
Cost Sensitivity to Relative Salesforce	0.08	Dimensionless	The change of total cost due to the relative change of salesforce. Source: NYK North America
Average Experience of LSO on New Hire	1	Years	Average experience of offering the logistics service of newly hired salesforce – assuming one year of experience
Initial Market Share of Carriers LSO	0.1	Dimensionless	Carriers' market share of offering the logistics service to shippers. It is assumed to be 10%.
Initial Perceived LSO Ratio Change	0	1 / Year	Initial perceived rate of change of the LSO ratio to be used for estimating the trend of LSO ratio change. It is assumed to be zero.
Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission	0.28	Fraction * Year	The impact of relative improvements of LSO capabilities on the indicated carriers commission. It is assumed to be as same as [Utilization Trend Sensitivity on Indicated Freight Rate], which is defined in the generic model.
Sensitivity of LSO Ratio Change Trend on Indicated Intermediaries Commission	-0.28	Fraction * Year	The impact of relative improvements of LSO capabilities on the indicated intermediaries commission. It is assumed to be as same as [Utilization Trend Sensitivity on Indicated Freight Rate] in an opposite direction.
Initial Carriers Commission	80	$ / TEU	Average commission charged by carriers for offering the logistics service. It is assumed to be 20% lower than the [Initial intermediaries Commission], reflecting the low initial LSO capability of carriers.
Initial Intermediaries Commission	100	$ / TEU	Average commission charged by intermediaries for offering the logistics service. Assuming that it is around $100 per TEU.
Maximum Allowable Commission by Shippers	200	$ / TEU	Maximum allowable commission paid by shippers. Assuming that it is around $200 per TEU.

Table 8-5 Data of Reference Points for the Decision-making in the LSO Dynamics

Variable Name	Value	Unit	Descriptions and Source
Initial Development Rate of Intermediaries LSO	0.07	Fraction / Year	Base increasing rate of the intermediaries' LSO due to its natural experience gain over time. It is assumed that intermediaries can improve their LSO capability by 7% per year at first and then decrease at a decreasing rate.
Annual Decay Rate of Development Rate	0.03	Fraction / Year	This is the control variable to test the different scenarios of the development of Intermediaries LSO.
Hiring Increase Rate for LSO	0	Dimensionless	The rate that carriers increase the hiring to improve the LSO; i.e., carriers should hiring more to improve the LSO. This is the control variable to test the impacts of carriers' decisions to adopt the different hiring rates per year to develop the LSO.
Switch for LSO Case of Hiring	0 or 1	Dimensionless	0 for Future Base Case (i.e., no impact of profitability on Salesforce); 1 for LSO Case (i.e., considering the impact of profitability on Salesforce hiring policy)
Switch for LSO Case of Experience by Salesforce	0 or 1	Dimensionless	0 for Future Base Case (i.e., no impact of learning on "Rate of Experience Gain); 1 for LSO Case (i.e., considering the impact of learning on "Rate of Experience Gain")
Switch for Revenue Increase from LSO	0 or 1	Dimensionless	0 for OFF (i.e., no revenue increase from the LSO); 1 for ON (i.e., considering the revenue increase from the LSO)
Switch for the Case of Variable Commission	0 or 1	Dimensionless	0 for OFF (i.e., Constant Commission for LSO), 1 for OFF (i.e., Variable Commission for LSO)
Switch for the Case of Variable Intermediaries LSO	0 or 1	Dimensionless	0 for OFF (i.e., constant "Intermediaries LSO") ; 1 for ON (i.e., variable "Intermediaries LSO")

Table 8-6 Data of the Information Delay Time in the LSO Dynamics

Variable Name	Value	Unit	Descriptions and Source
Shippers' Carriers LSO Perception Time	0.5	Years	Time for shippers to perceive the level of carriers LSO. It is assumed to be 6 moths.
Shippers' Intermediaries LSO Perception Time	0.5	Years	Time for shippers to perceive the level of intermediaries LSO. It is assumed to be as same as [Shippers' Carriers LSO Perception Time].
Time to Perceive and Clear the Hiring Needs	0.5	Years	Time to realize the hiring needs and prepare the hiring process. It is assumed to be 6 months.
Average Time Interval for Trend Estimation of LSO Ratio Change	0.5	Years	Time periods that carriers and intermediaries look at for estimating the change of LSO ratio. It is assumed to be 0.5 year.
Time to Perceive Relative LSO Ratio	0.5	Years	Time for carriers and intermediaries to realize the relative capability of their LSOs by comparing each other. It is assumed to be 6 months.
Time to Change Carriers Commission	1	Years	Time for carriers to change the commission for the LSO. It is assumed that carriers in general change the price structure once every year.
Time to Change Intermediaries Commission	1	Years	Time for intermediaries to change the commission for the LSO. It is assumed to be as same as [Time to Change Carriers Commission].

Furthermore, the table functions, which describe the six nonlinear relationships in the LSO dynamics, are presented in Table 8-7 and Table 8-8, followed by the graphs for each table function (Figure 8-15 ~ Figure 8-20).

Table 8-7 Nonlinear Relationships and Table Functions for the LSO Dynamics

Nonlinear Relationships	Table Functions	Input Variables
Effect of Relative Profitability on Hiring	TAB – Relative Profitability on Hiring	Adjusted Relative Profitability
Average Rate of Learning by Salesforce	TAB – Relative Salesforce on Rate of Learning	Relative Salesforce
Effect of Carriers LSO on Attractiveness of Carriers Service	TAB - Carriers LSO on Attractiveness of Carriers Service	Relative Carriers LSO
Effect of Intermediaries LSO on Attractiveness of Intermediaries Service	TAB - Intermediaries LSO on Attractiveness of Intermediaries Service	Relative Intermediaries LSO
Effect of Carriers Commission on Attractiveness of Carriers Service	TAB - Carriers Commission on Attractiveness of Carriers Service	Relative Carriers Commission
Effect of Intermediaries Commission on Attractiveness of Intermediaries Service	TAB - Intermediaries Commission on Attractiveness of Intermediaries Service	Relative Intermediaries Commission

Table 8-8 Description of the Table Functions in the LSO Dynamics

Table Functions	Comments	Figures
TAB – Relative Profitability on Hiring	Assuming that this is as same as "TAB - Relative Profitability on Order" in the generic model	Figure **8-15**
TAB – Relative Salesforce on Rate of Learning	Assuming that this is the linear relationship at a rate of 50% increase of "Average Rate of Learning" given the 100% increase of "Salesforce".	Figure **8-16**
TAB - Carriers LSO on Attractiveness of Carriers Service	The impact will increase at a decreasing rate. It is assumed that (1) the impact will take off from the 20% increase of LSO; (2) the impact will increase until the 500% increase of LSO; (3) and then the impact will get saturated after that.	Figure **8-17**
TAB - Intermediaries LSO on Attractiveness of Intermediaries Service	It is assumed that impact of relative improvement of intermediaries LSO on attractiveness is much less sensitive than that of Carriers LSO on attractiveness because the intermediaries LSO is more mature than the carriers LSO. So, the impact on attractiveness reaches twice when the Intermediaries LSO improves 5 times, whereas in the carriers LSO case the impact is assumed to be 5 times when the Carriers LSO improves 5 times. And, the impact is leveling off thereafter.	Figure **8-18**
TAB - Carriers Commission on Attractiveness of Carriers Service	Inverse proportional relationship is assumed. It is further assume that (1) there is relatively insensitive range of impact around 1 of "Relative Carriers Commission". The range is expected to be plus & minus 10% of 1; (2) maximum positive impact is 100% increase for the free LSO service (i.e., 0 of "Relative Carriers Commission); (3) maximum negative impact is 100% decrease at 100% increase of "Relative Carriers Commission and there after.	Figure **8-19**
TAB - Intermediaries Commission on Attractiveness of Intermediaries Service	Assuming that this is as same as the "TAB - Carriers Commission on Attractiveness of Carriers Service."	Figure **8-20**

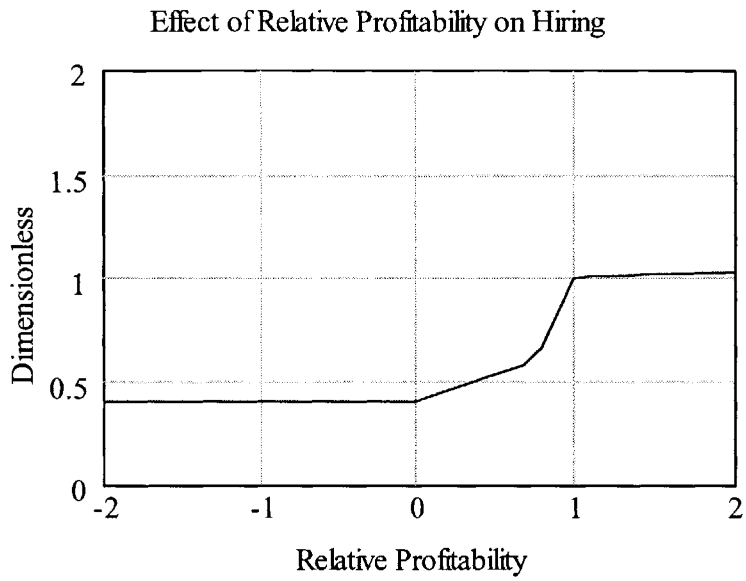


Figure 8-15 Effect of Relative Profitability on Hiring

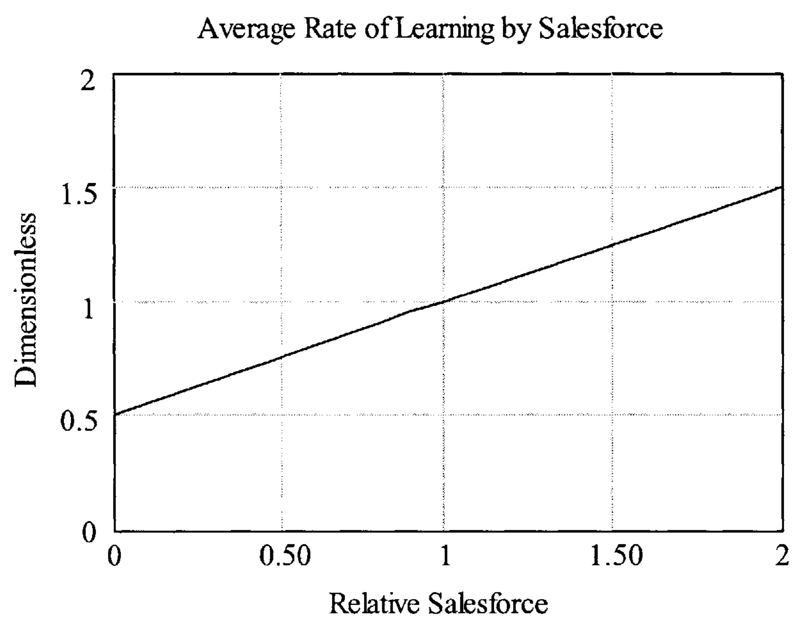


Figure 8-16 Average Rate of Learning by Salesforce

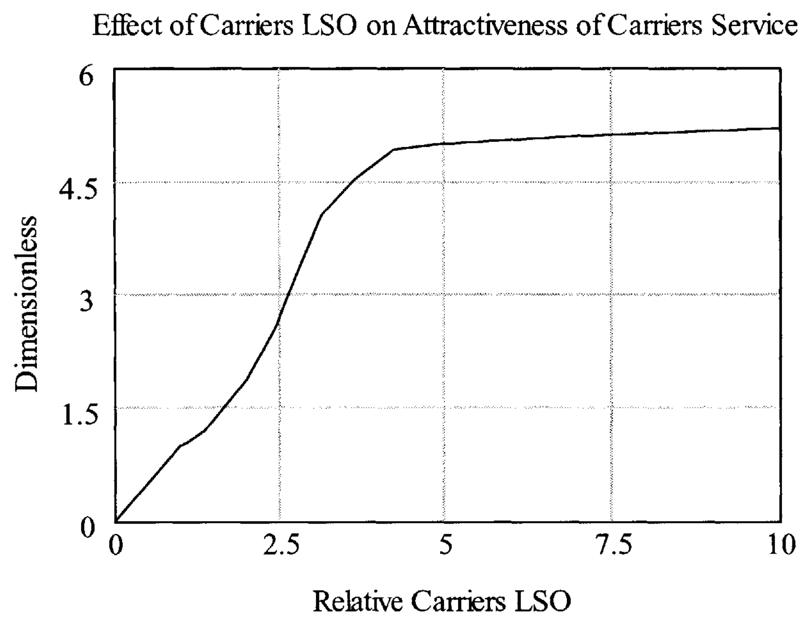


Figure 8-17 Effect of Carriers LSO on Attractiveness of Carriers Service

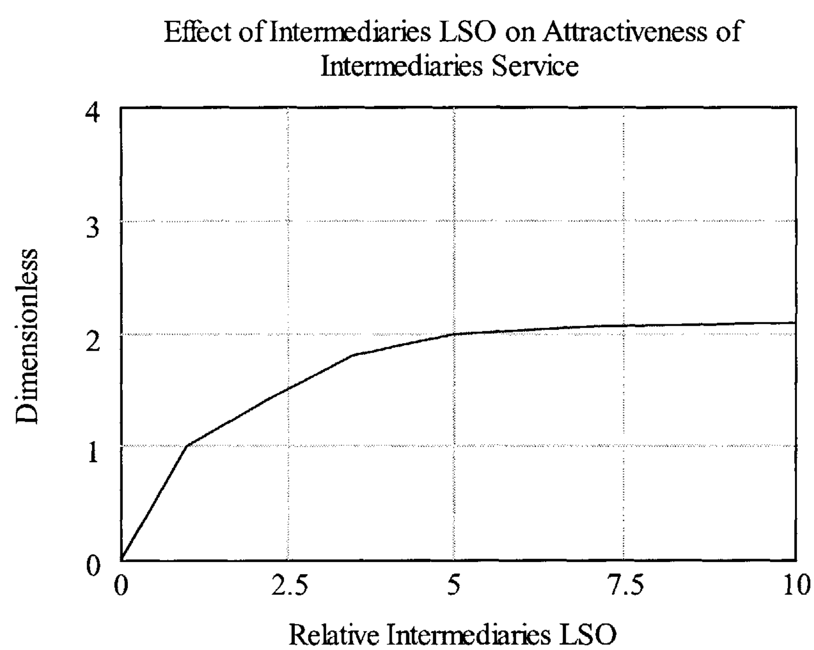


Figure 8-18 Effect of Intermediaries LSO on Attractiveness of Intermediaries Service

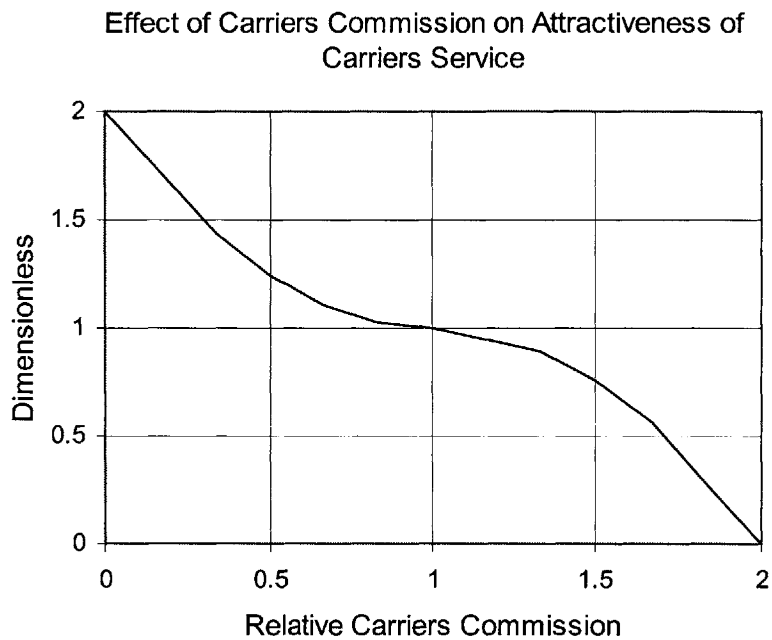


Figure 8-19 Effect of Carriers Commission on Attractiveness of Carriers Service

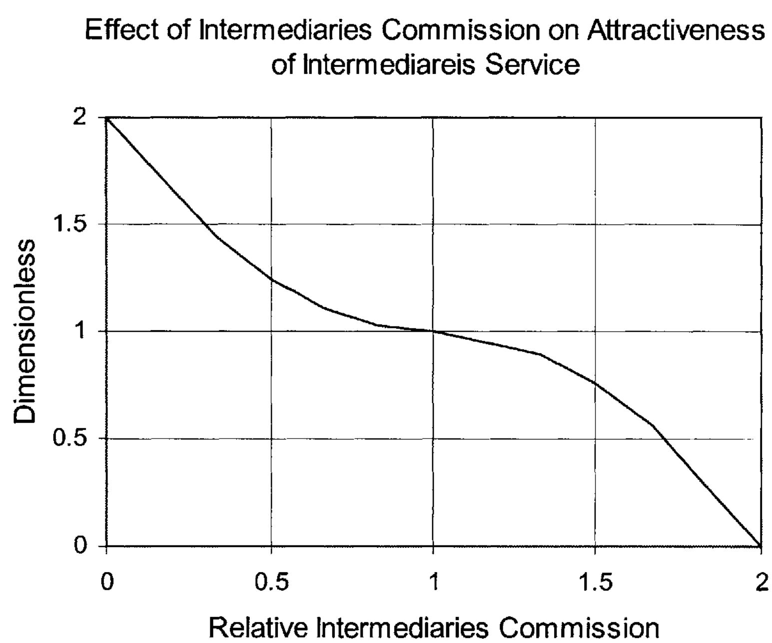


Figure 8-20 Effect of Intermediaries Commission on Attractiveness of Intermediaries Service

Meanwhile, the values of exogenous parameters for simulating the potential diffusion dynamics of e-business are adapted from those of the exogenous parameters for the EDI diffusion dynamics in the 1990s, which are shown in section 7.5.1. In other words, the exogenous parameters for the diffusion dynamics of e-business are set in such a way that the diffusion rate of e-business in the 2000s must be as same as that of EDI in the 1990s in the container shipping industry, which is the basic assumption in analyzing the impacts of e-business diffusion on the container shipping industry.

Table 8-9 presents the data for the exogenous parameters used in the e-business diffusion dynamics, and the nonlinear relationships for modeling the e-business diffusion, which are adapted from the EDI diffusion model, are provided in Figure 8-21, Figure 8-22, and Figure 8-23.

Table 8-9 Data of the Exogenous Parameters for the Diffusion Dynamics of e-Business

Variable Name	Value	Unit	Descriptions and Source
Total Players	1000	Company	This is the approximate total number of carriers, shippers, and intermediaries, which can potentially impact the container shipping industry, ignoring smaller players.
Initial e-Biz Users	50	Company	Initial "e-Biz diffusion rate by users" is assumed to be 5% in the year of 2001.
Contact Rate	11	1 / Year	A rate that total users interact each other during a certain period, i.e., measured in company contacted per potential e-biz users per time period, or [1/time]. The contact rate estimated in the EDI diffusion model is used in this model.
Effectiveness of Trading Partners' Demand	0.02	1 / Year	The fraction that potential e-biz users become active e-biz users due to the trading partners' demand. It is assumed to be 2% per year.
Normal Adoptability	0.015	Dimensionless	The fraction that contacts between potential e-biz users and e-biz users make potential e-biz users become active e-biz users. It is assumed to be around 1.5%.

Variable Name	Value	Unit	Descriptions and Source
Normal Attractiveness of e-Biz	1	Dimensionless	Reference level of attractiveness in 2001. It is set as unity for the simulation purpose.
Average Transactions per Container Shipping Demand	20	Transaction / TEU	It is assumed that on average twenty different transactions are required to transport a container. This is based on the number of EDI transaction sets to be used for container shipping (Sokol, 1995)
Average e-Biz Transactions per Users	1,050,000	Transaction / (Company * year)	This is the average e-biz transactions per e-biz users. It is estimated by from the calibration process that the shape of "e-biz diffusion rate by users" in the 2000s is as same as that of "EDI diffusion rate by users" in the 1990s.

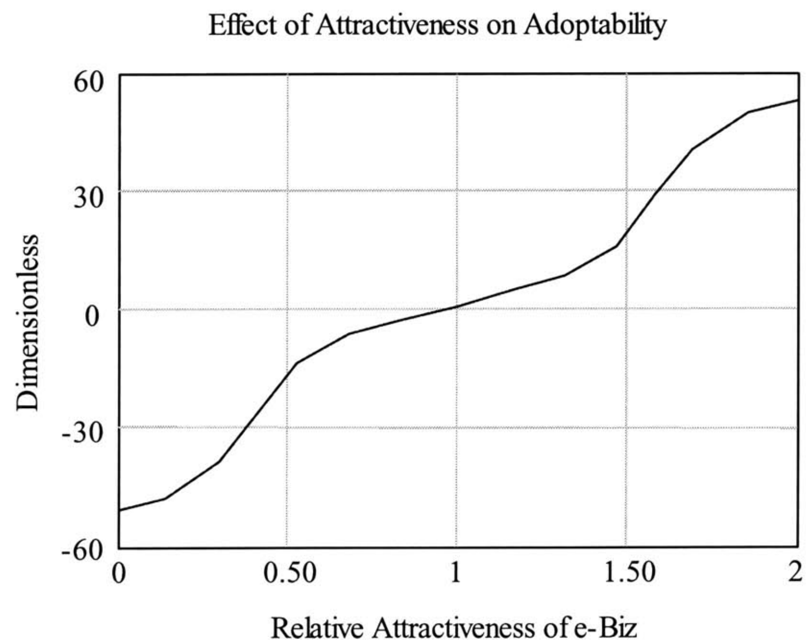


Figure 8-21 Effect of Attractiveness on Adoptability of e-Business

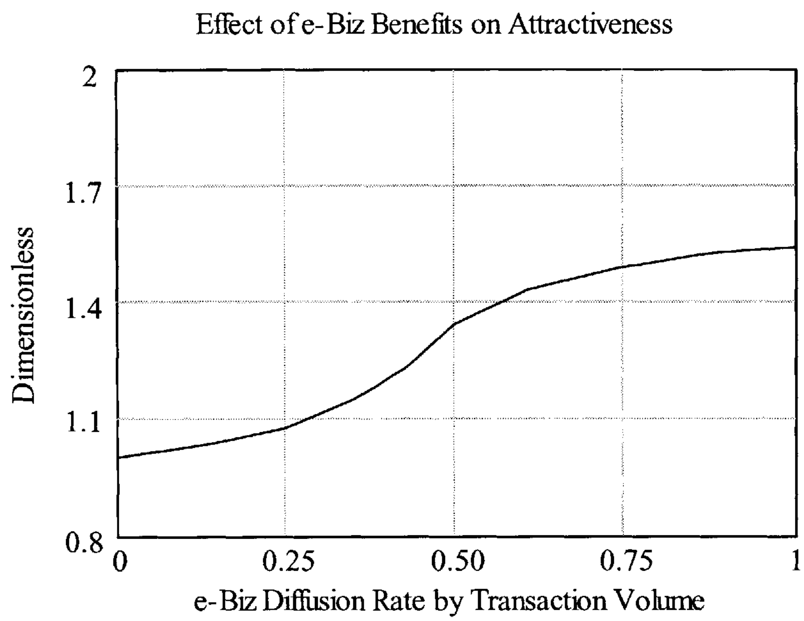


Figure 8-22 Effect of e-Business Benefits on Attractiveness of e-Business

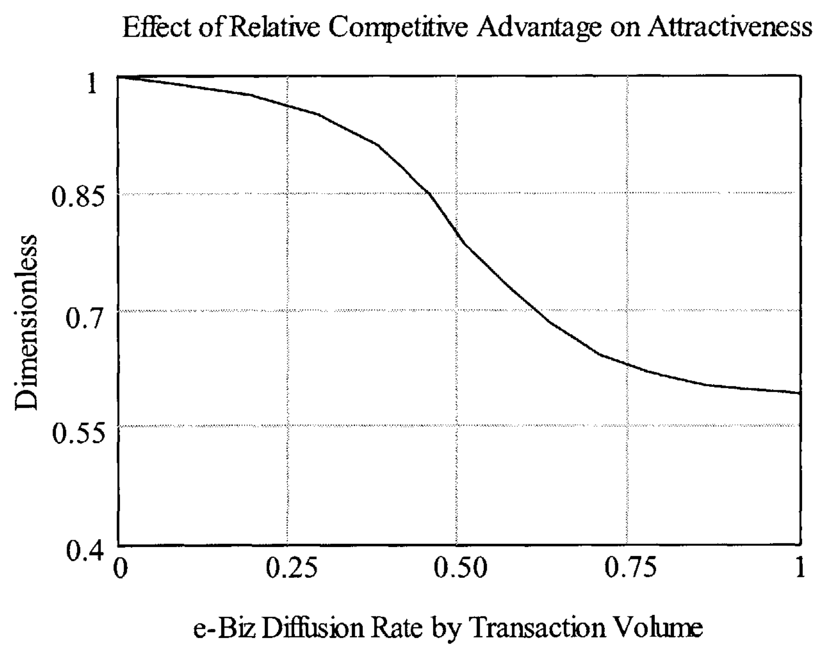


Figure 8-23 Effect of Relative Competitive Advantage on Attractiveness of e-Business

In addition, two new nonlinear relationships should be defined for analyzing the impacts of e-business on the CSI: "effect of e-biz diffusion on carriers cost" and "average rate of learning by e-biz." These nonlinear relationships explain how much the level of e-business adoption in the container shipping industry affects the overall cost of carriers and the rate of learning LSO by carriers' salesforce, respectively. Each nonlinear relationship is determined by the table functions describing the nonlinear relationships among the variables: The former is explained by the "TAB – eBiz Diffusion on Cost" while the latter is characterized by the "TAB – eBiz Diffusion on Rate of LSO Learning." Both relationships use the "e-biz diffusion rate by transaction volume" as an input variable. The detailed descriptions of each table function are provided in Table 8-10, followed by the figures of the table functions in Figure 8-24 and Figure 8-25.

Table 8-10 Description of the Table Functions in the Diffusion Dynamics of e-Business

Table Functions	Comments	Figures
TAB – eBiz Diffusion on Cost	In the early stage of e-Biz diffusion, carriers should pay relatively high cost for e-Biz. However, the carriers' cost will decrease as more carriers adopt e-biz at a decreasing rate, as the e-biz market gets mature over time. It is assumed that (1) carriers should spend 10% more on e-Biz until e-Biz diffusion is around 30%; (2) the cost starts to decrease from around 30% of e-Biz adoption rate until 70%; (3) the cost impact becomes unity from 50% of e-Biz diffusion; (4) the cost will stabilize after 70% of e-Biz diffusion; and (5) the final cost impact will stay around 2% lower, or 98% of original cost level.	Figure **8-24**
TAB – eBiz Diffusion on Rate of LSO Learning	The assumption for the base case is the linear relationship at a rate of 50% increase of "Average Rate of Learning by e-Biz" given the 100% of e-Biz diffusion rate by transaction volume.	Figure **8-25**

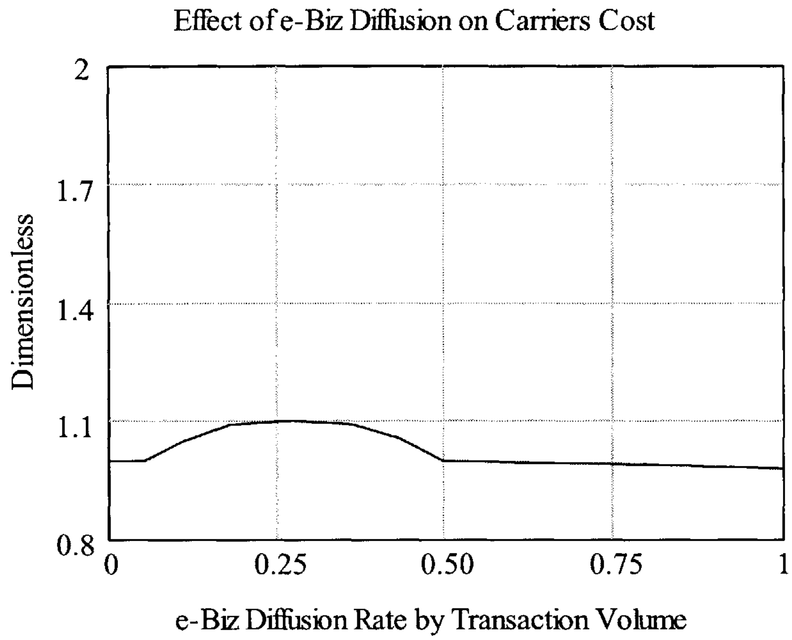


Figure 8-24 Effect of e-Biz Diffusion on Carriers Cost

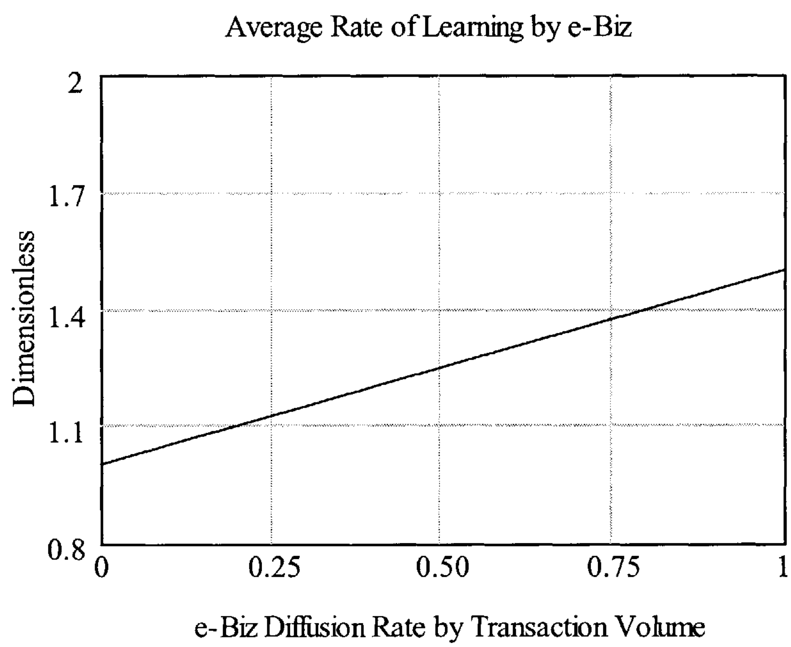


Figure 8-25 Average Rate of Learning by e-Biz

8.3.5 Simulation Results of the Integrated Model

After setting the exogenous parameters, the integrated model is used for analyzing the impacts of e-business on the container shipping industry. Three integration strategies of carriers – the vertical, virtual, and mixed integration strategy – for developing the LSO, as well as the future base case, in which carriers are assumed neither to develop the LSO nor to adopt the e-business, are tested with the integrated model.

In order to simulate the future base case and the three integration strategies of developing the LSO, seven control variables are used for activating or deactivating the specific feedback loops constituting each scenario (see Table 8-11). In the future base case, all control variables are set as zero so that there are no impacts from the logistics service in simulating the future base case. In the vertical integration strategy, it is assumed that (1) carriers increase the hiring rate by 50% more than the future base when the carriers' profitability is higher than the reference profitability; (2) the LSO commissions of carriers and intermediaries are changing depending on their levels of LSO capability; (3) and the intermediaries' LSO capability improves over time as set by the exogenous input. On the other hand, in the virtual integration strategy, carriers are assumed to improve their LSO capability by adopting e-business while the LSO commissions of carriers and intermediaries and the intermediaries' LSO capability improve over time as in the vertical integration strategy. Finally, in the mixed integration strategy, all control variables are turned on to reflect both the vertical and the virtual integration strategies at the same time, so that carriers are assumed to increase their LSO capability by both hiring additional salesforce and adopting e-business while the LSO commissions of carriers and intermediaries and the intermediaries' LSO capability improve over time as in the vertical integration strategy.

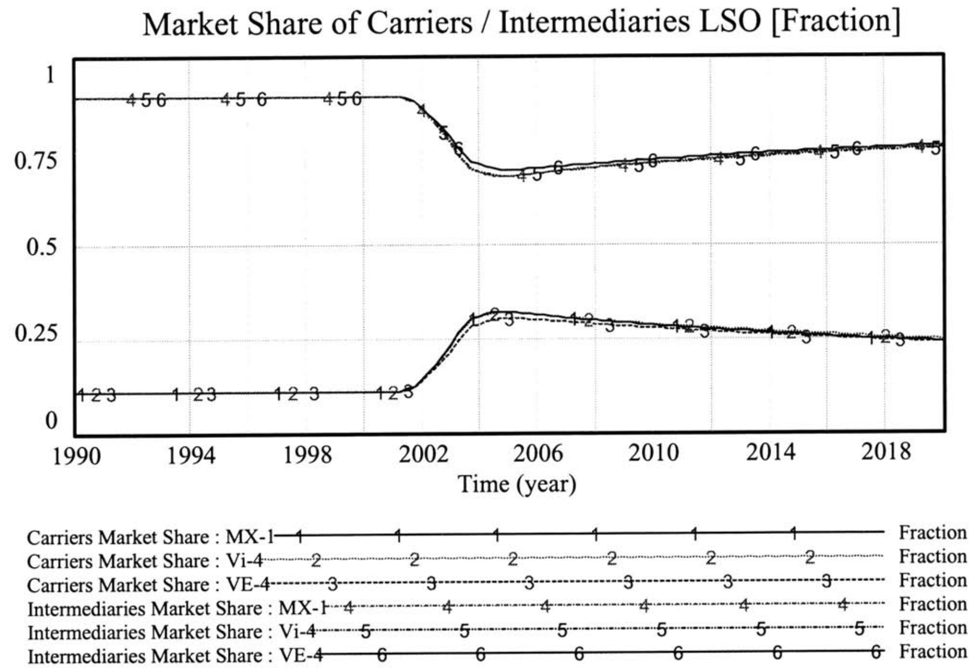
The model is simulated for each case for a time period from 1990 to 2020. The LSO dynamics and the diffusion dynamics of e-business are assumed to activate from the year of 2001. The simulation results of the integrated model are shown in the following.

Table 8-11 Scenarios for the Simulation of the Integrated Model

Control Variables	Future Base Case	Vertical Integration (VE-4)	Virtual Integration (Vi-4)	Mixed Integration (MX-1)
Hiring Increase Rate for LSO	0	0.5	0	0.5
Switch for LSO Case of Hiring (*)	0	1	0	1
Switch for LSO Case of Experience by Salesforce	0	1	0	1
Switch for Revenue Increase from LSO	0	1	1	1
Switch for LSO Case of Experience by eBiz	0	0	1	1
Switch for the Case of Variable Commission	0	1	1	1
Switch for the Case of Variable Intermediaries LSO	0	1	1	1

(*) For switch variables, 0 means being turned off and 1 means being turned on

Figure 8-26 presents the dynamic change of four important variables related to developing the LSO: the LSO market share of carriers and intermediaries, and the LSO commission levels of carriers and intermediaries. In general, the three strategies of developing the LSO provide similar trends over time. The carriers' LSO market share is expected to increase rapidly from 2001 to 2005 when carriers start to offer the logistics service, whereas the intermediaries' LSO market share decreases substantially during the same time period. After the year of 2005, however, the carriers' market share decreases slowly while the intermediaries' market share recovers over time. Finally, in the long term, both LSO market shares of carriers and intermediaries are expected to stabilize over time. Overall, the carriers' LSO market share will increase from 10% in 2001 to 25% in 2020 while that of intermediaries decreases from 90% to 75% during the same period.



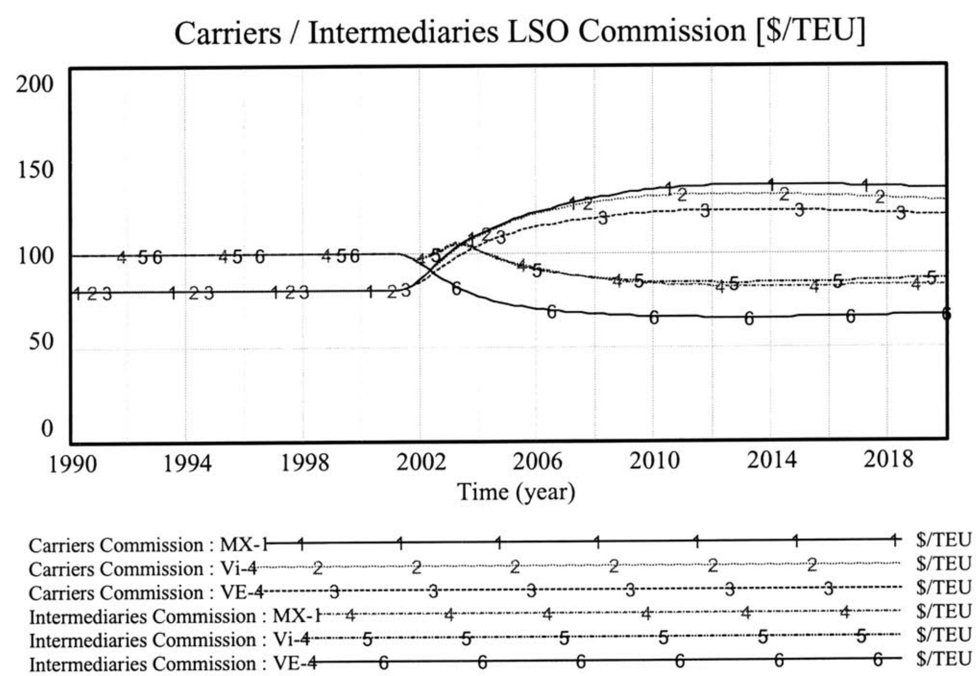


Figure 8-26 Dynamics of Developing the LSO in Three Different Strategies

Meanwhile, the LSO commission of carriers is expected to improve in the early days of developing the LSO whereas that of intermediaries decreases during the same time period. In the long term, both LSO commission levels of carriers and intermediaries stabilize over time. Eventually, the carriers' LSO commission becomes higher than the intermediaries' LSO commission.

Closely reviewing the causal relationships and the model structure, the behaviors of LSO market share and commission level can be explained as follows: When carriers first start to improve their LSO capability by hiring additional salesforce and increasing the quality of logistics service with e-business, the increase rate of carriers' LSO capability is much higher than that of intermediaries' LSO capability while the LSO commission levels are similar, making the carriers' logistics service look more attractive to shippers than the intermediaries' logistics service. Accordingly, the carriers' LSO market share will increase faster in the early days of developing the LSO while the intermediaries' LSO market share decreases. However, as carriers' logistics service improves, carriers tend to raise their LSO commission level, reflecting their improved service and harvesting the initial investment for developing the LSO. Meanwhile, realizing the erosion of LSO market share, intermediaries will try to undercut the price of logistics service in order to protect their LSO market share from the fast improving LSO capability of carriers. As such, the LSO commission of carriers increases while that of intermediaries decreases in the early days of LSO development.

On other hand, the increase rate of carriers' LSO capability will become slower over time. Intermediaries will continue to improve their logistics service and to keep their LSO commission level lower than the carriers', so that they can improve their LSO capability and compete with carriers. Therefore, the carriers' LSO market share will start to decrease slowly after reaching the highest market share whereas the intermediaries' LSO market share will be slowly recovering over time. By the same token, the LSO commission of carriers will decrease slowly while that of intermediaries will increase slowly over time. Finally, in the long term, both the market shares and the commission levels of carriers and intermediaries are expected to be stabilized and to reach the equilibrium points.

Figure 8-27 again confirms the dynamics of developing the LSO as explained above. Although both the carriers' and the intermediaries' LSO capability generally improve over time, the carriers' LSO capability increases faster than the intermediaries' in the early days, and so does the attractiveness of carriers' logistics service, which explains the fast improvement of carriers' market share in the early days of developing the LSO. In the long term, however, the attractiveness of intermediaries' logistics service slowly increases whereas that of carriers rather stabilizes, which supports the fact that both the LSO market shares of carriers and intermediaries will reach the equilibrium levels.

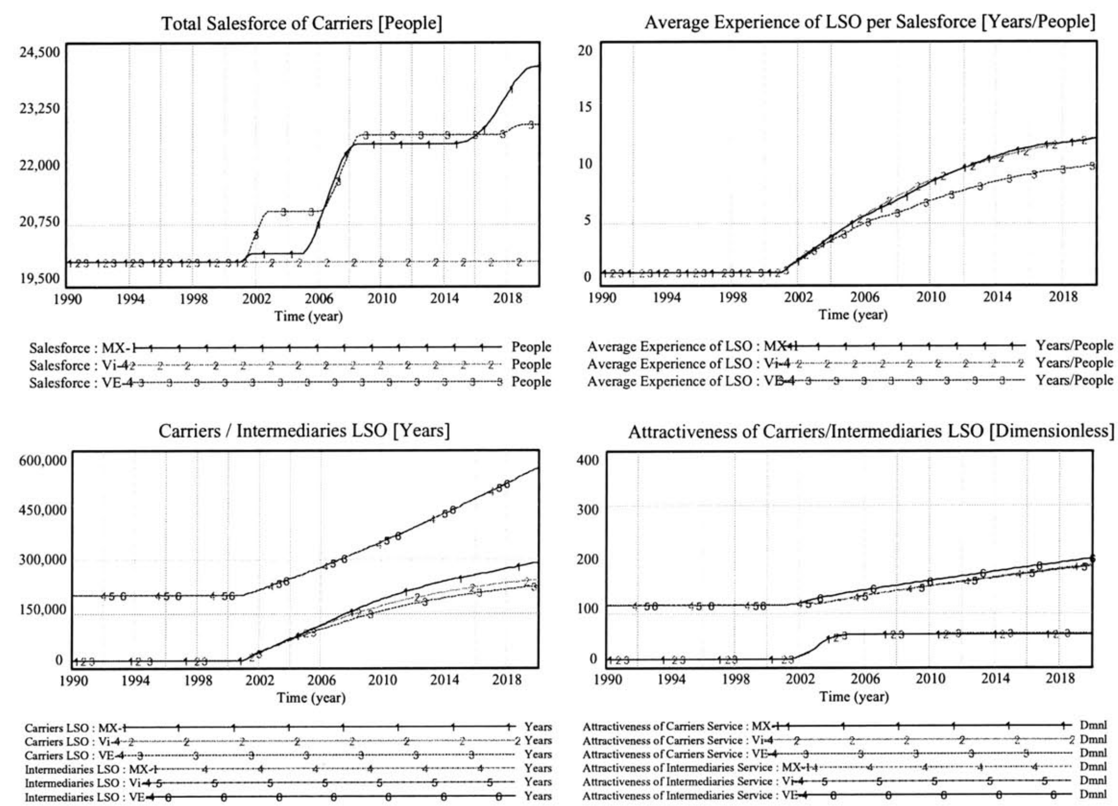


Figure 8-27 Improvement of the LSO Capabilities of Carriers and Intermediaries

Meanwhile, the dynamics of developing the LSO should impact the generic dynamics of supply-and-demand in the container shipping industry. In fact, it is expected that the improved market share of carriers in the logistics service market should provide additional revenue to carriers and generate better profitability if the cost of offering the logistics service is effectively controlled. This turns out to be true from the simulation results as shown in Figure 8-28, which compares the cases of three integration strategies with the future base case. Although the freight rate in cases of developing the LSO is similar to that in the future base case, carriers make additional revenue from the logistics service (the "unit revenue increase from LSO") while limiting the overall unit costs of offering the logistics service similar to that of the future base case. Thus, the carriers' long-term profitability is expected to be higher than the future base case.

One interesting behavior is the utilization data. The utilization in cases of developing the LSO is much lower than that of the future base case. The main reason for this behavior is that the improved profits from the logistics service are used for expanding the containership capacity in the model. The detailed discussion on the behavior of utilization is presented in section 8.4.4.

In addition to simulating the model for the three strategies of developing the LSO, a set of sensitivity analysis is performed to identify the critical parameters for determining the carriers' profitability. Furthermore, a batch of Monte-Carlo simulation, or multivariate sensitivity analysis, is also performed to test the model's behavior responding to the random inputs of the critical parameters, which are identified from the sensitivity analysis. The detailed information on the sensitivity analysis and the Monte-Carlo simulation can be found in section 8.4.1. Finally, based on the critical parameters identified from the Monte-Carlo simulation, the optimistic and pessimistic scenarios – i.e., the scenario analysis – are developed and tested with the integrated model. The scenario analysis and the findings from the analysis are provided in detail in section 8.4.7.

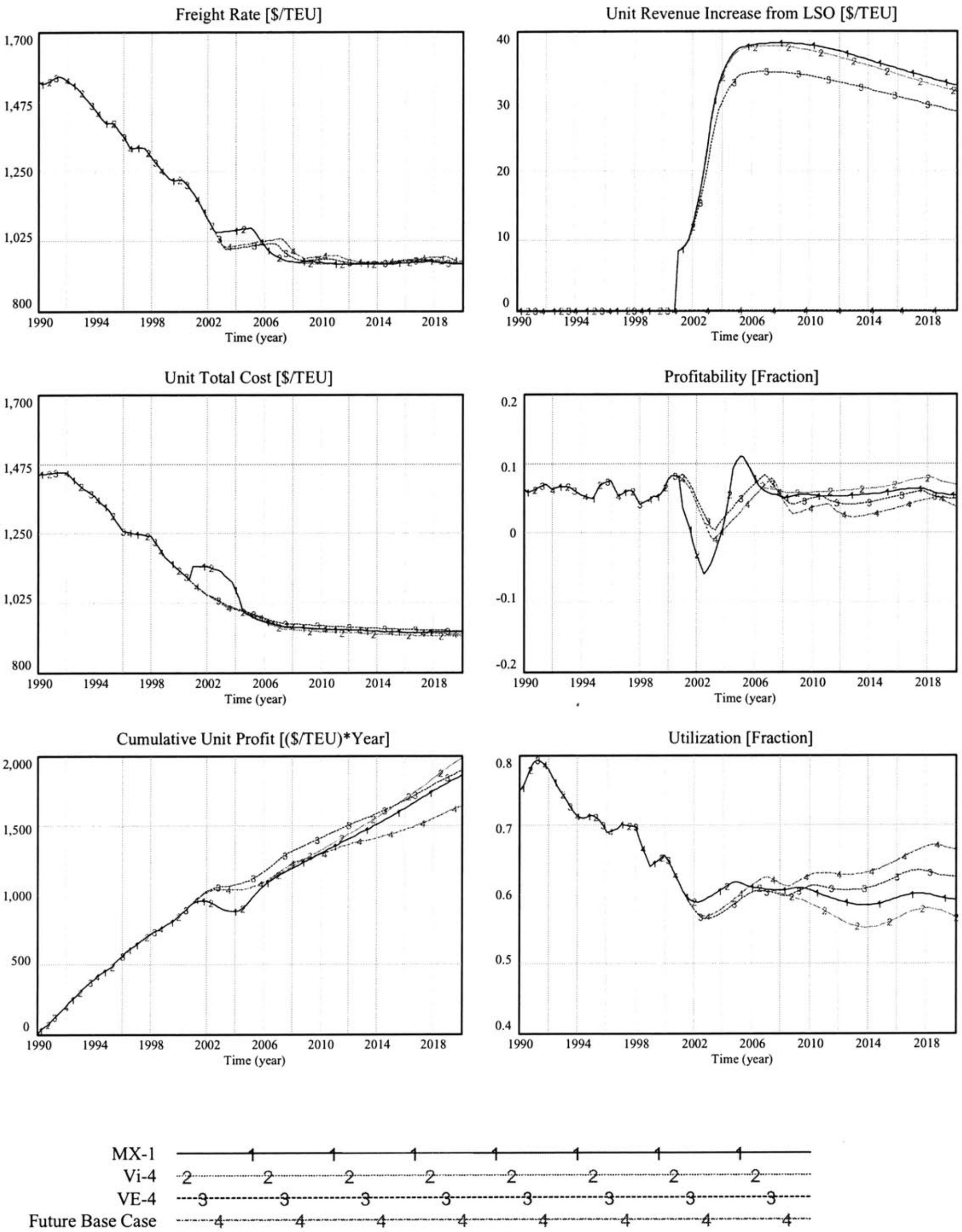


Figure 8-28 Impacts of Developing the LSO on the Supply-and-Demand Dynamics in the CSI

8.4 Major Findings from the Integrated Model on the Impacts of e-Business on the CSI

Seven major findings on the impacts of e-business on the container shipping industry can be drawn from the simulation of integrated model. Table 8-12 shows the summary of the major findings. The detailed discussions of each finding are provided in the following.

Table 8-12 Findings from the Integrated Model on the Impacts of e-Business

1. There is no doubt that **the strategies of developing the LSO** could **improve the carriers' long-term profitability**.
2. The improved profitability from the LSO mainly stems from the **efficient cost management** compared to the revenue increase from the LSO, i.e. controlling the costs is the most important factor.
3. **Faster industry-wide diffusion of e-business**, which helps carriers lower the overall cost, will improve the carriers' long-term profitability.
4. However, the container shipping service will be **further commoditized** despite the improved carriers' profitability.
5. Then, the key question is where to reinvest the improved profits – there might be **two choices of investment**.
    a. Investing in expanding the containership capacity
    b. Investing in further developing the LSO capability
6. Depending on where to reinvest the improved profits from the LSO and e-business, **two scenarios of potential structural changes in the container shipping industry** are expected – carriers **need to make a strategic decision** for their future business.

7. Whatever the carriers' strategic decision may be, it is recommended that carriers **expand the containership capacity more wisely and conservatively** to be more profitable.

8.4.1 Improved Long-term Profitability of Carriers by Offering the LSO

The first finding from the simulation results is that offering the logistics service can improve the carriers' long-term profitability substantially. Figure 8-29 shows that the long-term profitability of carriers in developing the LSO is much higher than that of the future base case, which does not provide the logistics service. Specifically, the carriers' profitability after the year of 2007 is better than that of the future base case. In addition, the cumulative unit profit, representing the carriers' cumulative profit per TEU over time, also demonstrates that the strategies of developing the LSO are better than the future base case. Among the three strategies of developing the LSO, the virtual integration strategy, which purely utilizes the e-business to offer the logistics service, provides the best long-term profitability.

However, in the short term, the profitability of developing the LSO is lower than that of the future base case. The reason for this is that carriers must initially invest a significant amount of money in developing the logistics service. Particularly, both the virtual and the mixed integration strategies are more expensive in the early days of developing the LSO than the vertical integration strategy, in which the profitability is always slightly higher than the future base case.

Overall, the carriers' profitability in any case of developing the logistics service is expected to be better in the long term than that of future base case, while carriers should endure the initial loss due to the investment in developing the logistics service.

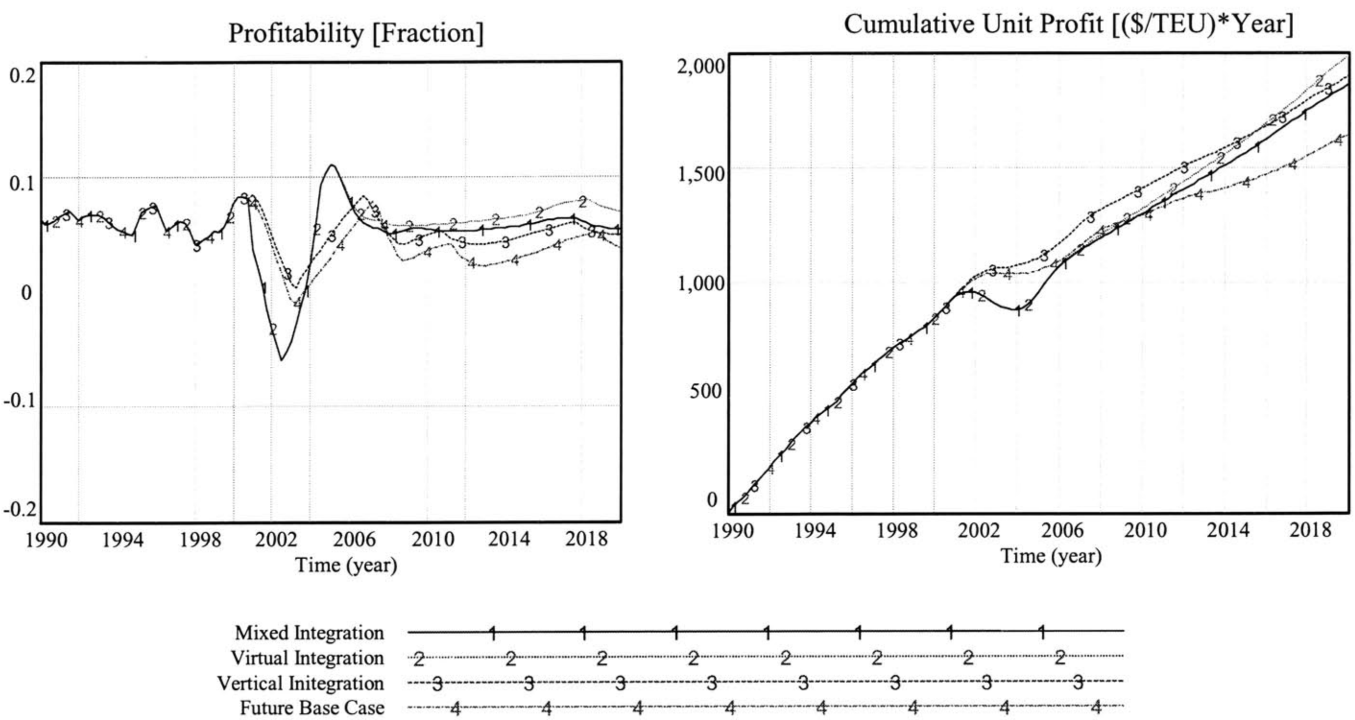


Figure 8-29 The Profitability of Carriers in Developing the LSO

In order to ensure the claim that the LSO could provide better profitability to carriers, a batch of Monte-Carlo simulations (or "multivariate sensitivity analysis") for each integration strategy is performed. In other words, the system's sensitivity to a group of important parameters is tested through the Monte-Carlo simulations.

The parameters used for the Monte-Carlo simulations are selected in two stages. First, a set of simulations is performed varying the exogenous parameters (i.e., the "sensitivity analysis"). The cumulative unit profit of carriers is used as the main indicator of the system's performance and only one parameter is modified per simulation. The sensitivity analysis provides the most critical parameters that are influential to the system's performance.[48] Next, among the critical parameters, only those that are controllable by carriers are selected to be used for the Monte-Carlo simulations. Therefore, the Monte-Carlo simulations are performed using a group of parameters, which are critical and controllable by carriers.

[48] The detailed results of the sensitivity analysis are discussed in the Appendix.

The result of the Monte-Carlo simulations for the mixed integration strategy, which is the most realistic option that carriers could take, is presented in the following.[49] Eight parameters are selected for the Monte-Carlo simulations in the mixed integration strategy (see Table 8-13 and Figure 8-30). The parameters can be divided into four categories depending on their characteristics. Two of those parameters are related to the impact of cost in developing the logistics service (parameter (2) and (8)); three of them are related to controlling the level of diffusion rate of e-business (parameter (1), (4), and (7)); two of them are relevant to the carriers' LSO capability (parameter (3) and (5)); and finally parameter (6) is representing how much carriers would increase their salesforce to offer the logistics service. These parameters are assumed to have a uniform distribution around the values in the model, and the range is set to cover 25% of upper and lower of the value. Randomly selected values of each parameter are used for the simulation and a total of 200 different simulations are performed.

Table 8-13 Parameters for the Monte-Carlo Simulations in the Mixed Integration Strategy

Parameters for the Monte-Carlo Simulation	1. Effect of relative competitive advantage on attractiveness 2. Effect of e-business diffusion on cost 3. Effect of carriers LSO on attractiveness of carriers service 4. Effect of e-business benefits on attractiveness 5. Time to change carriers commission 6. Hiring increase rate for LSO 7. Contact rate 8. Cost sensitivity to relative salesforce

[49] The Monte-Carlo simulations for other cases such as the vertical and the virtual integration strategy provide the similar results to those of the mixed integration strategy.

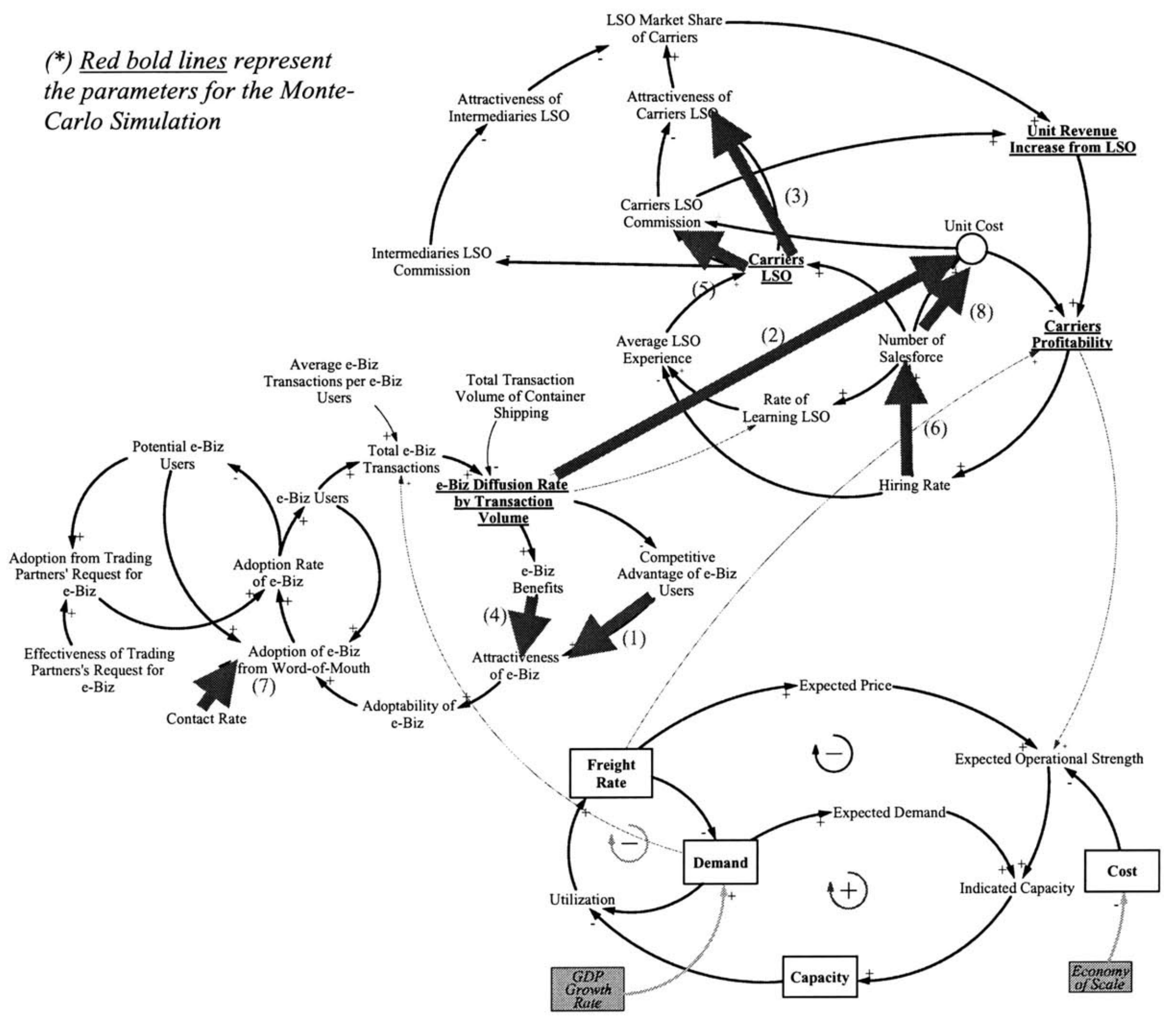


Figure 8-30 Parameters for the Monte-Carlo Simulations on the Causal Loop Diagram

Figure 8-31 shows the sensitivity histogram of the cumulative unit profit at the year of 2020 in the mixed integration strategy. In other words, the figure presents the distributions of the cumulative unit profit at the year of 2020 among the 200 different simulations, which are performed with randomly selected combinations of eight parameters. The range for the cumulative unit profit in the future base case, which is 1,636 [($/TEU)*Year], is also specified in the figure. The figure confirms that the majority of the Monte-Carlo simulations provides better cumulative unit profit than that of the future base case. More than 50% of the simulations generate the cumulative unit profit in the range of 1,800 and 1,950 [($/TEU)*Year]. The average of the range, 1,875 [($/TEU)*Year], is around 15% higher than the cumulative unit profit in the future base case.

In addition, Figure 8-32 shows the distribution of the cumulative unit profit over time with 50% and 95% confidence bounds and the cumulative unit profit in the future base case, which is represented in a red dotted line. This figure also confirms that the long-term cumulative unit profit in the mixed integration strategy with randomly selected combinations of parameters is still higher than that of the future base case, even though the early cumulative unit profit after developing the LSO is lower than that of the future base case.

Meanwhile, Figure 8-33 presents the distribution of the carriers' profitability over time with 50% and 95% confidence bounds and the carriers' profitability in the future base case. Similar to the cumulative unit profit, the carriers' long-term profitability is expected to be better than that of the future base case.

As such, the Monte-Carlo simulations clearly confirm that the strategies of developing the LSO could improve the carriers' long-term profitability substantially. Therefore, if carriers start to offer the logistics service to shippers by either hiring additional salesforce (i.e., the vertical integration strategy) or adopting the e-business actively (i.e., the virtual integration strategy), it is expected to provide better profitability to carriers in the long term.

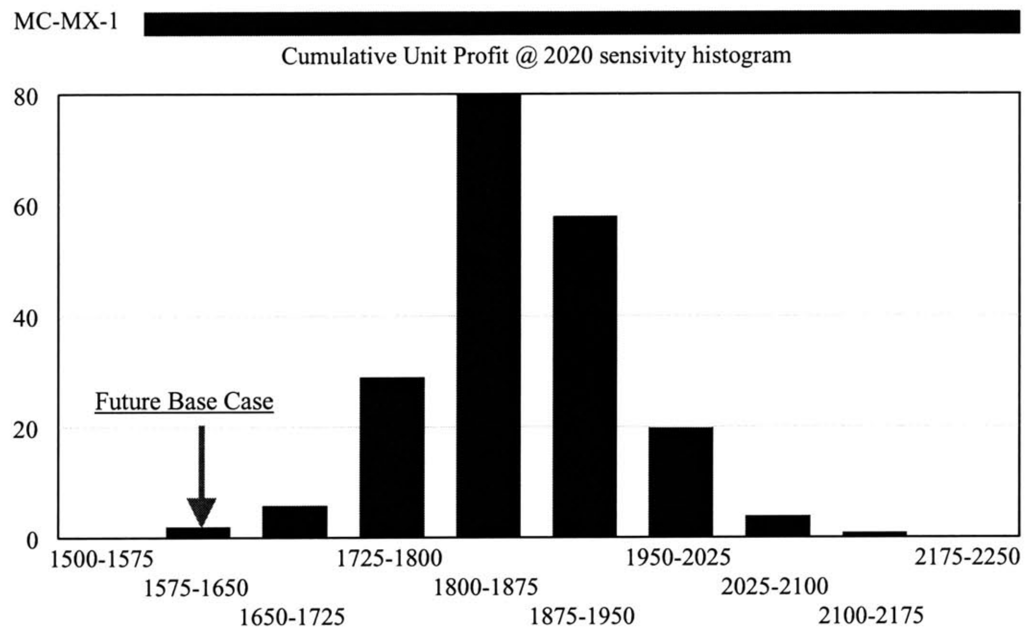


Figure 8-31 Sensitivity Histogram of "Cumulative Unit Profit" in the Mixed Integration Strategy

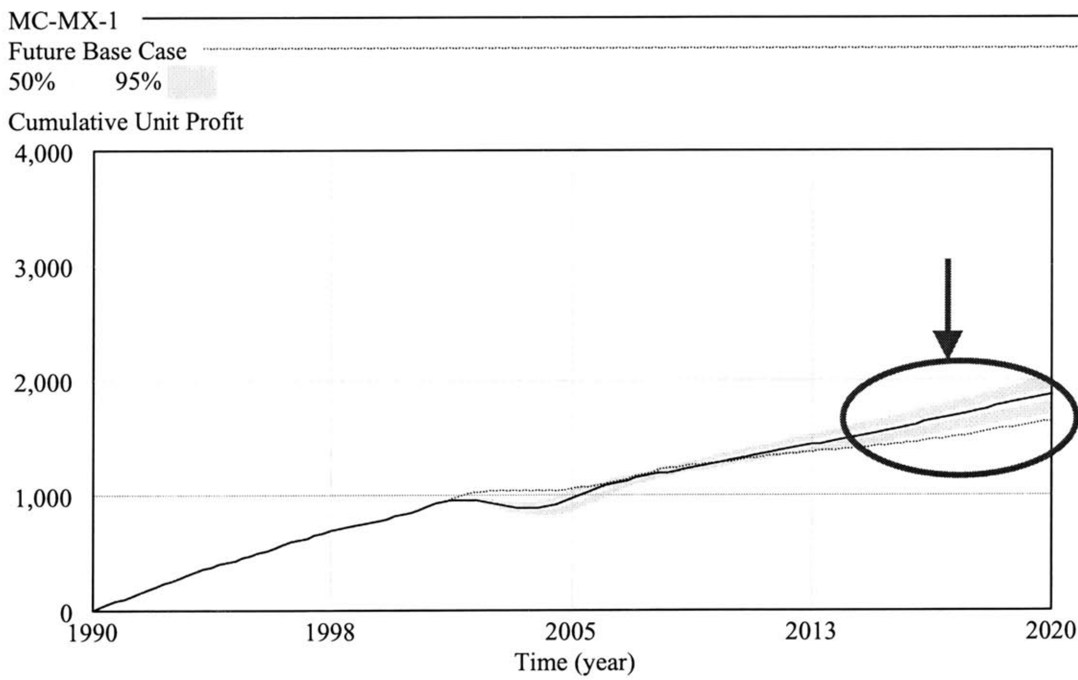


Figure 8-32 Monte-Carlo Simulations - "Cumulative Unit Profit" in the Mixed Integration Strategy

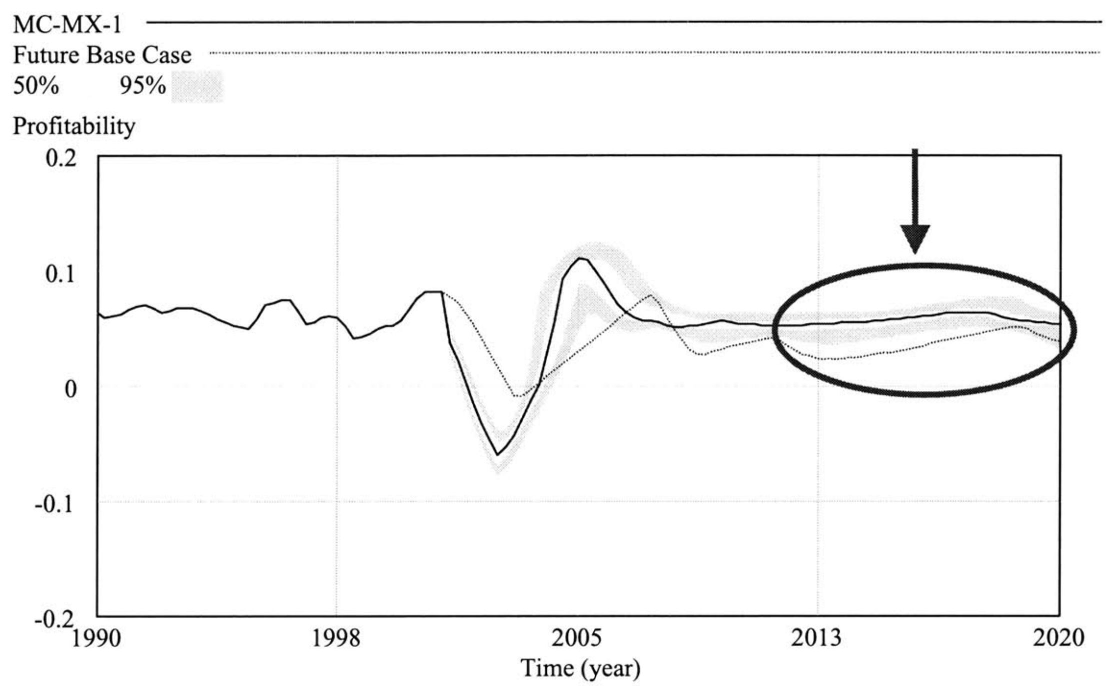


Figure 8-33 Monte-Carlo Simulations - "Profitability" in the Mixed Integration Strategy

8.4.2 Importance of Efficient Cost Management in Developing the LSO

The first finding that offering the logistics service could provide carriers with better profitability leads to the next question – what makes the carriers' profitability improve by offering the logistics service? In general, there are two factors that determine the carriers' profitability: revenue and cost. Reviewing the simulation results and the sensitivity analysis that helps identify the critical factors impacting the carriers' profitability, it is concluded that, even though the LSO could provide additional revenue to carriers, the efficient cost management in developing the LSO is the key to improving the carriers' profitability. The detailed supporting evidences are explained in the following.

Let us first review the revenue side of the carriers' profitability. When carriers start to offer the logistics service to shippers, carriers should have two sources of revenue: One is the freight rate, which is the service charge for transporting a container from origin to destination, and the other is the revenue from LSO (or the variable of "unit revenue increase from LSO" in the model), which is the service charge per TEU for rendering the logistics service to shippers. Both revenue sources are measured in a dollar per TEU term. Figure 8-34 shows the freight rate and the unit revenue increase from LSO over time when carriers offer the logistics service with three different integration strategies, as well as those in the future base case. The figure confirms that the strategies of developing the LSO can generate additional revenue from the logistics service while the future base case provides no additional revenue to carriers. However, the freight rate in offering the logistics service is similar to that of the future base case in the long term. Therefore, the logistics service could be the major source of increased revenue to carriers if they start to offer the logistics service.

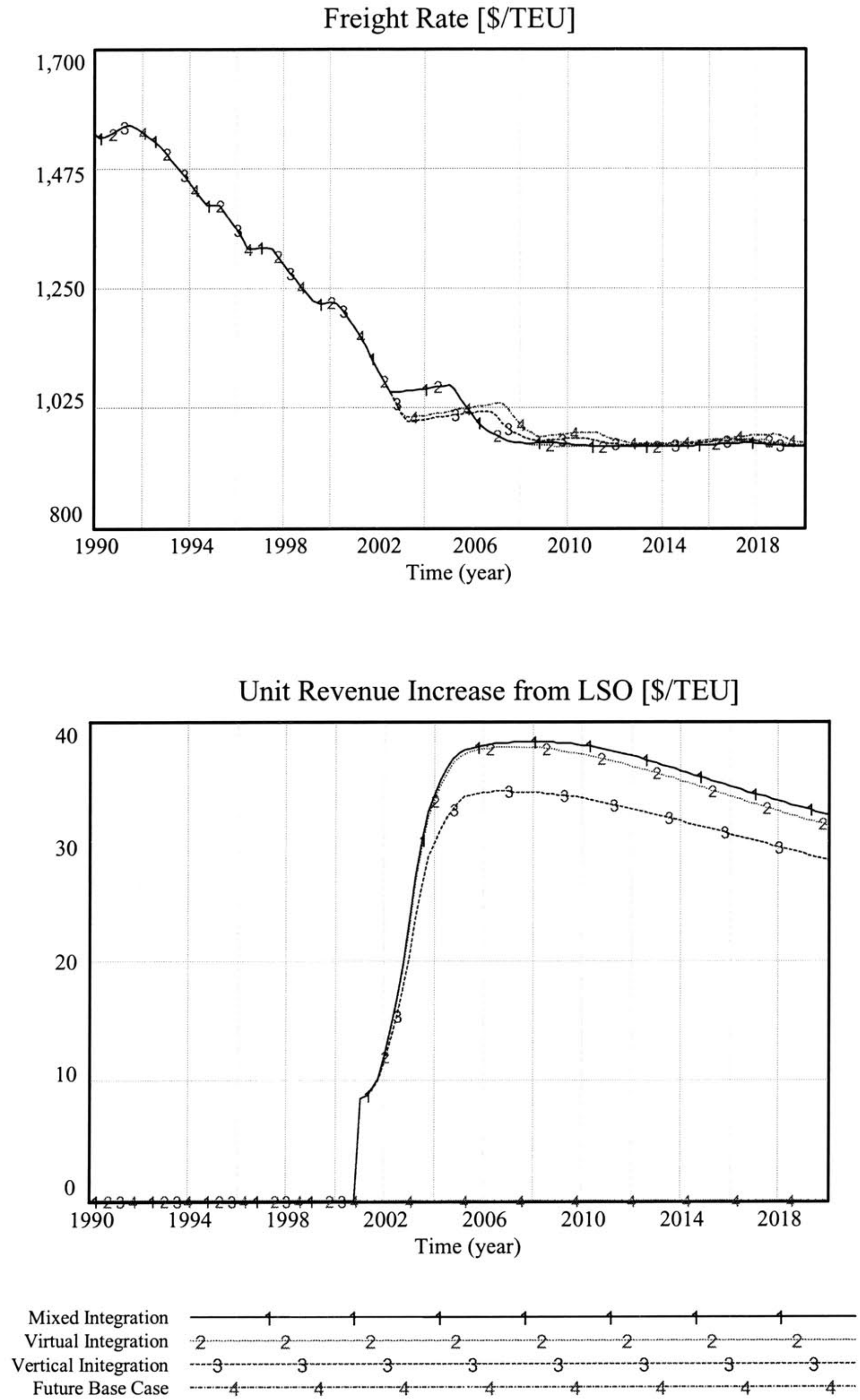


Figure 8-34 Revenue of Carriers in Developing the Logistics Service

Although Figure 8-34 confirms that the LSO could improve the carriers' revenue, it does not necessarily ensure that the carriers' profitability could also be improving. Rather, the cost side of the profitability should be closely examined. In other words, even if the revenue could increase due to the LSO, the cost of developing the LSO should be lower than the level of revenue in order to improve the carriers' profitability. As such, Figure 8-35 presents the trend of the carriers' unit total cost, measured in a dollar per TEU term, for the three integration strategies as well as the future base case. Notably, although developing the LSO requires additional investment in the early days, the long-term unit cost structure of offering the logistics service is similar to that of the future base case. Particularly, the difference of the long-term unit cost between the LSO cases and the future base is very limited compared with the unit revenue increase from the LSO in Figure 8-34. Overall, the LSO cases in general could provide additional revenue to carriers while limiting the additional unit cost similar to the future base. Accordingly, the long-term profitability of carriers in cases of offering the logistics service is expected to be better than that of the future base case and both revenue and cost side contribute to improving the carriers' profitability from the LSO.

Meanwhile, although the simulation results confirm that both revenue and cost are important to improving the carriers' profitability, it is not yet clear which of them is more critical to the improvement of carriers' profitability. In other words, it is necessary to know how the carriers' profitability could change if the parameters controlling the revenue and cost of offering the logistics service vary from the base case – i.e., identifying the critical parameters to the carriers' long-term profitability. For this purpose, the sensitivity analysis should be performed and closely investigated.

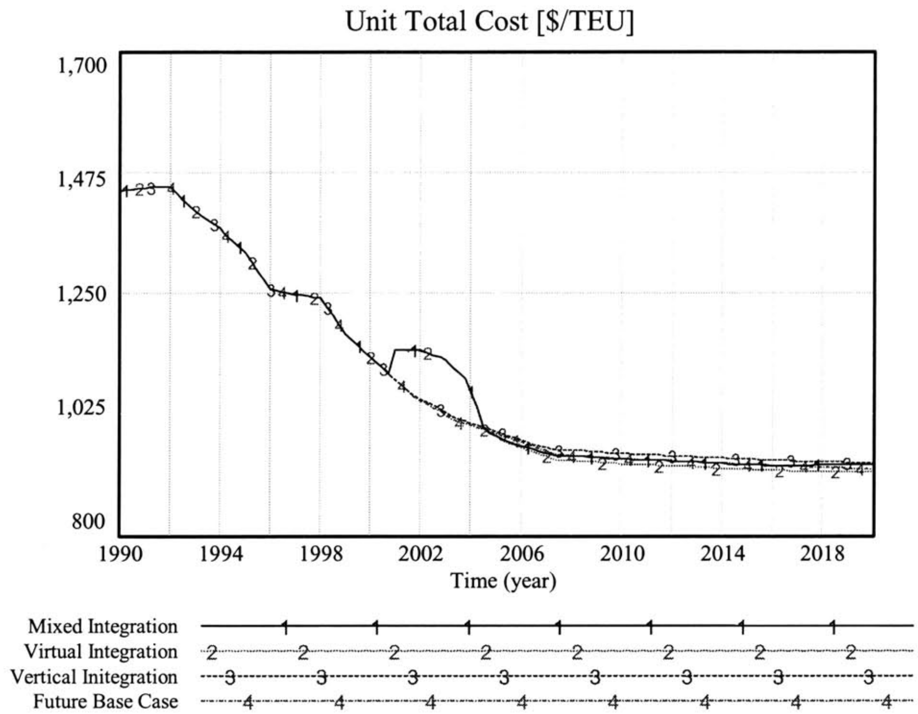


Figure 8-35 Unit Total Cost of Carriers in Developing the Logistics Service

Table 8-14 Critical Parameters for the Three Integration Strategies

Vertical Integration	Virtual Integration	Mixed Integration
1. Effect of Carriers LSO Attractiveness on Carriers Service	1. Effect of Relative Competitive Advantage on Attractiveness	1. Effect of Relative Competitive Advantage on Attractiveness
2. Time to Change Carriers Commission	2. Effect of e-Biz Diffusion on Carriers Cost	2. Effect of e-Biz Benefits on Attractiveness
3. Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission	3. Effect of Carriers LSO Attractiveness on Carriers Service	3. Effect of e-Biz Diffusion on Carriers Cost
4. Initial Development Rate of Intermediaries LSO	4. Effect of e-Biz Benefits on Attractiveness	4. Effect of Carriers LSO Attractiveness on Carriers Service
5. Hiring Increase Rate	5. Time to Change Carriers Commission	5. Time to Change Carriers Commission
6. Cost Sensitivity of Relative Salesforce	6. Initial Development Rate of Intermediaries LSO	6. Initial Development Rate of Intermediaries LSO
		7. Hiring Increase Rate

Setting the cumulative unit profit of carriers as the main indicator of performance, the sensitivity of the model is tested by changing the exogenous parameters. The parameters used for the sensitivity analysis are chosen based on the criteria that (1) the values of parameters were assumed in the simulation due to the lack of available data so that many uncertainties were assumed to be included in the parameters; or (2) the parameters are expected to impact the system's performance substantially from a point of the model structure. Each of the selected parameters is varied ±25% and only one parameter is modified per simulation.

While the detailed results and discussion of the sensitivity analysis can be found in the Appendix, Table 8-14 summarizes the critical parameters by the order of importance for the three integration strategies of developing the LSO identified from the sensitivity analysis. It can be found that the critical parameters for the three strategies are similar. The critical parameters in the mixed integration strategy, which is the most realistic case, are apparently the sum of those in the vertical and the virtual integration strategies.

To illustrate the critical parameters more clearly, Figure 8-36 presents the maximum percentage change of the cumulative unit profit due to the variation of each parameter in the mixed integration strategy. The figure shows that some parameters, which are in the upper part of the figure, change the system's performance substantially, while a couple of parameters, which are in the lower part of the figure, provide the limited impacts on the system's performance. Table 8-15 summarizes the critical parameters and the insignificant parameters identified from the sensitivity analysis.

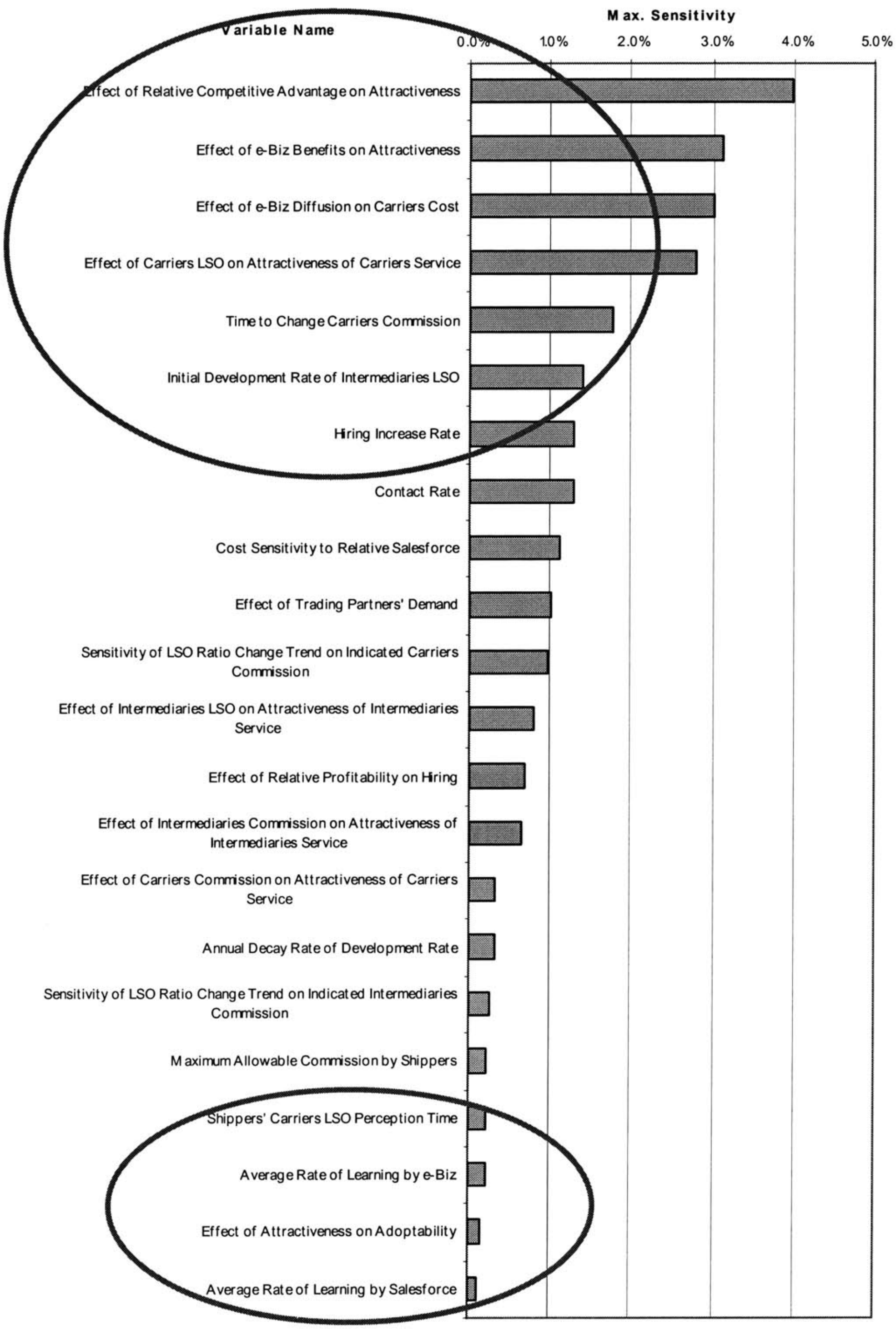


Figure 8-36 Sensitivity Chart for the Mixed Integration Strategy

Table 8-15 Summary of Sensitivity Analysis - Critical and Insignificant Parameters for the Carriers' Profitability in the Integrated Model

Category	Relevant Parameters	Comments
e-Business Diffusion Related Parameters	• Effect of Relative Competitive Advantage on Attractiveness • Effect of e-Biz Benefits on Attractiveness • Contact Rate • Effect of Trading Partners' Demand	Factors that help improve the adoptability of e-business improve the carriers' profitability most substantially.
Carriers-related Critical Parameters	• Cost Sensitivity to Relative Salesforce • Hiring Increase Rate for LSO	Managing the cost of hiring additional salesforce is the most important to improve the carriers' profitability.
	• Effect of e-Business Diffusion on Cost	The benefit of cost savings from adopting the e-business helps carriers increase their profitability substantially.
	• Effect of Carriers LSO on Attractiveness of Carriers Service	Increasing the effect improves the carriers' profitability.
	• Time to Change Carriers Commission • Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission	Quicker change of the carriers LSO commission level is desirable.
Intermediaries-related Critical Parameters	• Initial Development Rate of Intermediaries LSO	Faster improvement of the intermediaries' LSO capability decreases the carriers' profitability.
Insignificant Parameters	• Shippers Carriers LSO Perception Time	Advertising the improvement of the carriers' LSO capability is not effective in increasing the carriers' profitability.
	• Average Rate of Learning by e-Biz • Average Rate of Learning by Salesforce	Improving the experience of selling LSO through e-business or interactions among salesforce is not effective in increasing the carriers' profitability.
	• Effect of Attractiveness on Adoptability	The change of nonlinear relationship between the attractiveness of e-business service and its adoptability does not vary the cumulative profit of carriers substantially.

Summarizing the sensitivity analysis, there are four ways of improving the carriers' profitability from the LSO:

(A) Controlling the cost with developing the LSO effectively
(B) Diffusing the e-business faster in the container shipping industry through the word-of-mouth process
(C) Increasing the impact of carriers' LSO capability on the attractiveness of carriers' LSO service
(D) Changing quickly the carriers' LSO commission level depending on the level of carriers' LSO capability

The marked relationships in Figure 8-37 present the four ways of improving the carriers' profitability from the LSO.

Among the four ways of improving the carriers' profitability identified from the sensitivity analysis, the freshest insight, which is counter-intuitive, is the first one – controlling the cost in developing the LSO effectively. The sensitivity analysis shows that the less hiring of the salesforce, the better the carriers' profitability. Intuitively speaking, it is reasonable that hiring additional salesforce could improve the carriers' profitability because more salesforce will increase the carriers' LSO capability and the attractiveness of carriers' logistics service, thereby improving the unit revenue increase from the LSO. However, it turns out that the balancing dynamics relating to hiring additional salesforce, in which more salesforce will increase the cost of offering the logistics service to shippers, offset the additional revenue gain from the increased number of salesforce, so that the carriers' profitability in case of hiring additional salesforce decreases. In other words, the cost side of developing the LSO is more important than the revenue side of the LSO in order to improve the carriers' profitability.

In addition, the sensitivity analysis shows that the more cost savings from the e-business, the better the carriers' profitability. In the integrated model, the e-business is assumed to provide two benefits to carriers in developing the LSO as the diffusion rate of e-business increases over time: (1) reducing the overall unit total cost of carriers and (2) improving the carriers' LSO capability by making the carriers' salesforce be more experienced and sophisticated through utilizing e-business. The sensitivity analysis shows that, between the two benefits, the benefit of reducing the unit total cost is critical to the cumulative unit profit of carriers (i.e., the sensitivity of the parameter of "effect of e-business diffusion on cost" in Figure 8-36) while the benefit of improving the carriers' LSO capability is rather insignificant to the system's performance (i.e., the sensitivity of the parameter of "average rate of learning by e-biz" in Figure 8-36).

In summary, the second finding from simulating the integrated model is that the efficient cost management in developing the LSO is the key to improving the carriers' profitability. It is therefore recommended that carriers should focus more on the cost aspect in developing the logistics service, rather than just generating the additional revenue from the LSO without considering the cost associated with it. Unless the cost of providing the logistics service is properly managed, the potential improvement of carriers' profitability from the LSO could be elusive.

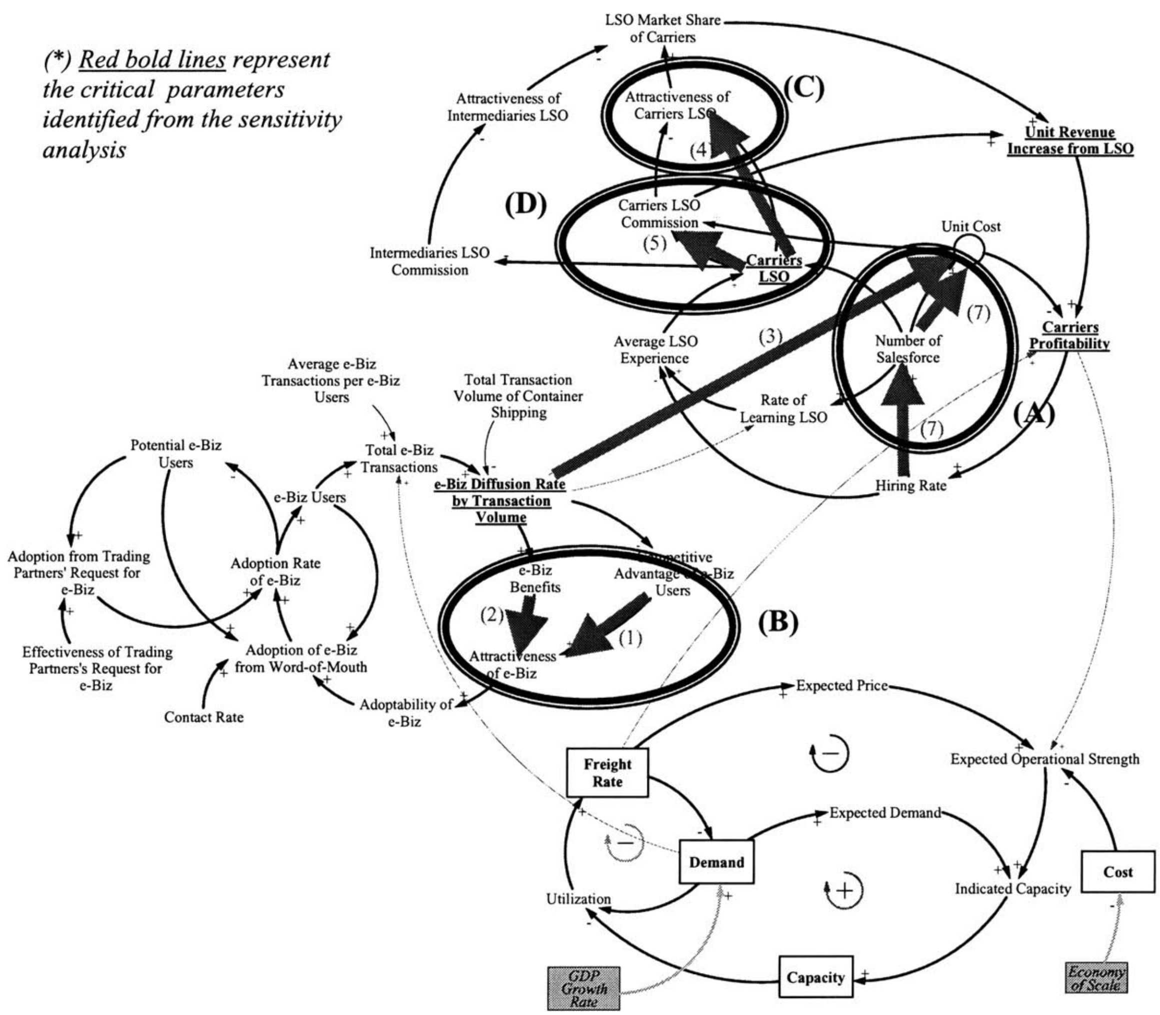


Figure 8-37 Critical Parameters in the Mixed Integration Strategy

8.4.3 Faster Industry-wide Diffusion of e-Business to Improve the Carriers' Long-term Profitability

The third finding from the simulation is that the faster industry-wide diffusion of e-business will improve the carriers' long-term profitability substantially. Particularly, among the two processes of diffusing the e-business – the trading partners' request and the word-of-mouth process (see Chapter 7 for the details) – the word-of-mouth process turned out to be more influential to changing the rate of e-business diffusion in the container shipping industry. The faster the e-business is diffused in the container shipping industry through the word-of-mouth process, the better the long-term profitability of carriers. The supporting evidence for this finding is as follows.

As discussed in section 8.4.2, diffusing e-business faster in container shipping through the word-of-mouth process is identified as one of the four ways of improving the carriers' profitability from the LSO. The sensitivity chart for the mixed integration strategy (see Figure 8-36) clearly confirms that the parameters that are related to the word-of-mouth process – "effect of relative competitive advantage on attractiveness" and "effect of e-biz benefits on attractiveness" – are the first and second important factors of changing the carriers' cumulative unit profit. In addition, the sensitivity of e-business diffusion rate to several exogenous parameters (see Appendix for the details) shows that those two parameters are expected to be most influential to changing the diffusion rate of e-business over time.

Furthermore, it should be noted that carriers could expect to lower the overall unit total cost as the e-business diffusion rate increases, and the impact of cost savings from the adoption of e-business also helps improve the carriers' long-term profitability, as discussed in section 8.4.2. In fact, the sensitivity chart for the mixed integration strategy (see Figure 8-36) shows that the parameter of "effect of e-business diffusion on cost," which determines the amount of cost savings as the diffusion rate of e-business increases, is identified as the third critical factor to improve the carriers' long-term profitability. In summary, the more diffusion of e-business due to the more active word-of-mouth process, the more cost savings of carriers is expected, thereby, improving the carriers' long-term profitability. Therefore, this evidence corroborates the third finding that faster industry-wide diffusion of e-business through the word-of-mouth process, which helps carriers lower the overall unit cost, will improve the carriers' long-term profitability.

8.4.4 Further Commoditization of the Container Shipping Service

The fourth finding from the modeling is that despite the improved carriers' profitability, the container shipping service is expected to be further commoditized in the future. This finding is counter-intuitive and surprising because the original purpose of developing the LSO is to reverse the trend of commoditization of the container shipping service by providing the value-added service to shippers (see section 2.6 for the details on the purpose of LSO). Although the LSO could improve the carriers' overall profitability by generating additional revenue from the logistics service, the simulation results show that the freight rate of container shipping service is expected to be further depressed and the problem of overcapacity could be more serious than the future base case. This finding is one of surprising findings from the system dynamics modeling in this research – It is not until the simulation results of the integrated model are closely reviewed that it is realized that the LSO could aggravate the commoditization of the container shipper service.

Figure 8-38 shows the freight rate and utilization in cases of developing the LSO, comparing with those in the future base case. The freight rate in cases of developing the LSO is in general lower than that of the future base. Furthermore, the utilization for the LSO cases is estimated to be much lower than that of the future base case. Compared with the trend of carriers' profitability (see Figure 8-29), it is clear that, despite the improved carriers' long-term profitability, offering the logistics service lowers the freight rate and the utilization relative to the future base case. In fact, the freight rate in cases of developing the LSO decreases at such a low level in the long term, getting closer to the variable cost of container shipping service after the year of 2012. Therefore, although the difference of utilization in the mixed integration strategy and that in the future base case becomes substantial after 2012, the freight rates after 2012 in two cases rather remains depressed and hardly recover. In summary, the container shipping service itself could be further commoditized over time in cases of offering the logistics service to shippers.

Then, what is the reason for this surprising behavior related to the commoditization of the container shipping service? The main reason for the further commoditization is that carriers are assumed in the model to maintain the current ways of investing in the containership capacity. In other words, as the carriers' profitability increases due to offering the logistics service with e-business, carriers have additional cash that should be reinvested. If carriers continue to use the same strategy as they have been doing – or "growing fast with bigger ships" when the market looks promising, they would like to reinvest the cash in acquiring additional containerships to drive down the unit cost and increase the market share: i.e., without differentiating the LSO-generating profits from the profits generated by the container shipping service, carriers, which stick to the traditional strategy of "growing fast with bigger ships," are supposed to add up the profits from the LSO and those from the container shipping service and to expand the containership capacity more aggressively using the improved profits from the LSO. Accordingly, there could be a substantial amount of excess capacity in the long term so that the utilization of the containership capacity would decrease further. Therefore, the freight rate would be further depressed and tight control of overall cost becomes more important. This outcome is contradictory to the original purpose of developing the LSO, in which carriers try to fight against falling profitability, utilization, and freight rate of the container shipping service.

Figure 8-39 presents the causal relationship (the red bold line) that drives the further commoditization of the container shipping service over time. This figure clearly explains that the increased profits from the logistics service are expected to improve the carriers' financial strengths, which makes carriers reinvest the increased profits in the containership capacity further.

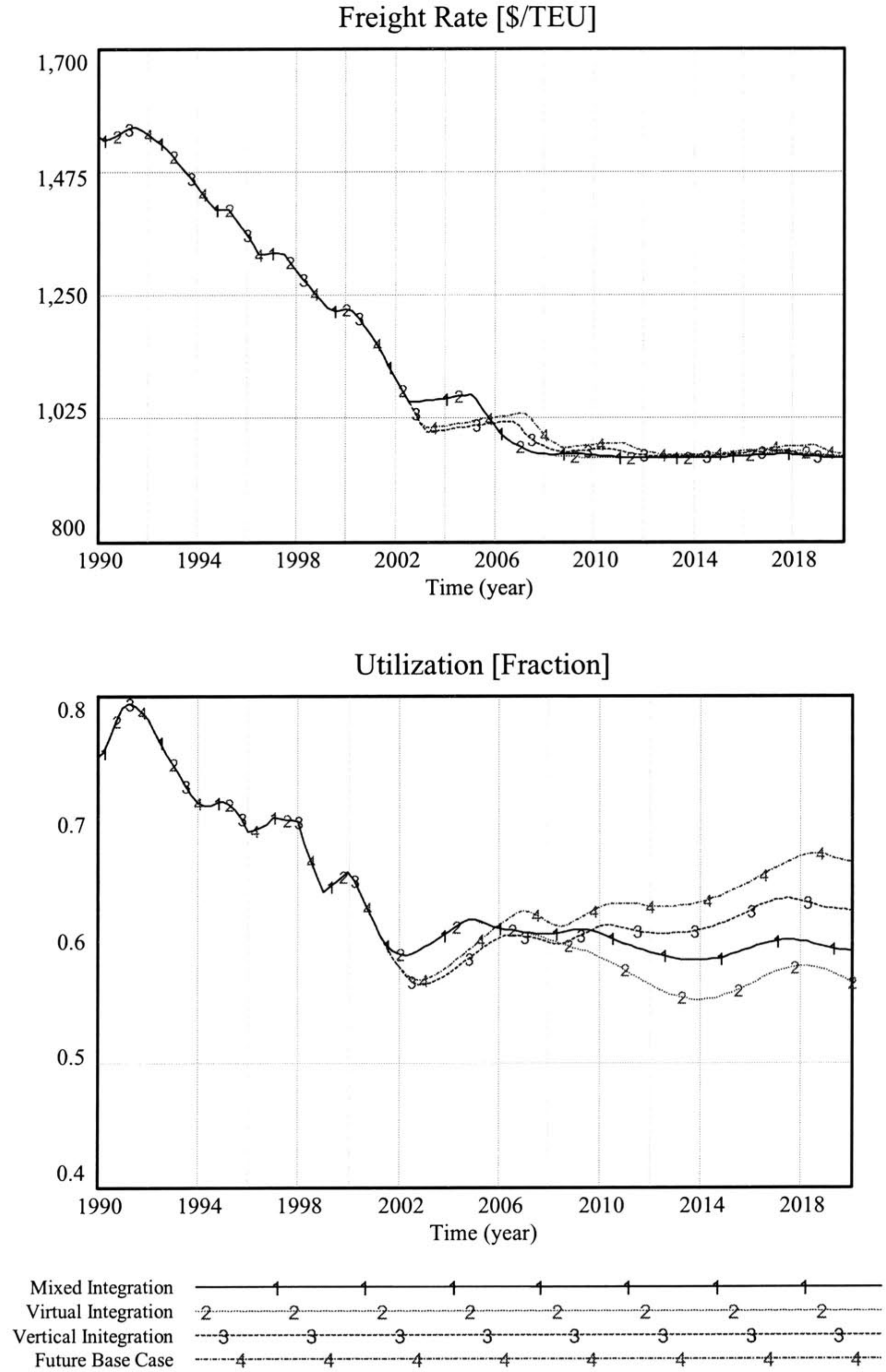


Figure 8-38 Freight Rate and Utilization in Developing the LSO

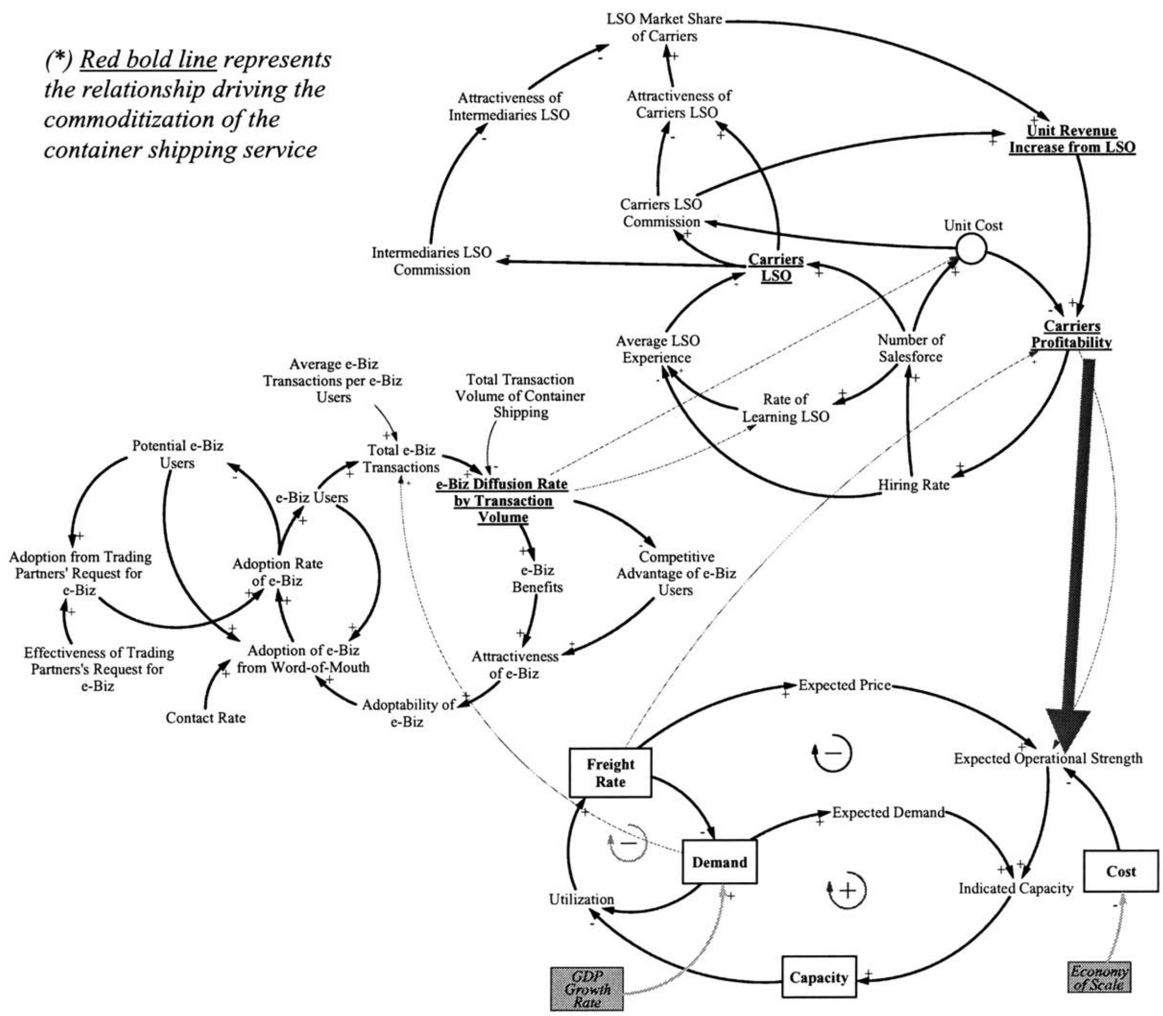


Figure 8-39 The Causal Relationship Driving the Further Commoditization

8.4.5 Two Choices of Investment Using the Improved Profits

The fourth finding above presents an important strategic question to carriers – where to reinvest the improved profits from the logistics service. There might be two choices of investment in general. This is the fifth finding from the simulation.

The first option is to reinvest the improved profits in expanding the containership capacity further, just as they have been doing so far. This option might be a natural decision to carriers, whose core competence has been to transport the containers efficiently from port to port. By acquiring the bigger containerships which are also technologically more advanced than the older containerships, carriers could move more containers, more economically and much faster. However, as shown in the simulation results, unless carriers increase the containership capacity more wisely, this choice could further commoditize the container shipping service over time.

The second option of reinvesting the improved profits is to develop the carriers' LSO capability further, rather than expanding the containership capacity. In other words, noting that the container shipping service itself could be commoditized over time even without the logistics service (see section 8.2), carriers would focus more on the logistics service, letting the container shipping service be commoditized as it is. This option could provide better profitability to carriers than the first option as shown from the simulation results. However, taking this option means that carriers should change the focus of their business model, from the container-transporting service providers to the logistics management service providers. Therefore, changing the business focus could entail huge unknown risks to carriers.

Depending on which option carriers choose, potential structural changes in the container shipping industry are expected, as discussed in the next section.

8.4.6 Two Scenarios of Potential Structural Changes from the LSO and e-Business

Based on the carriers' choice in response to reinvesting the improved profits from the LSO and e-business, there could be two scenarios of potential structural changes in the container shipping industry. To some degree, both scenarios are expected to change the current business dynamics in the container shipping industry. Carriers are therefore required to prepare themselves for the potential structural changes whatever their choice would be.

The first scenario is to reinvest the improved profits in expanding the containership capacity. As the simulation results show, this choice is highly likely to commoditize the container shipping service further, mainly because of the huge excess capacity driven by the faster expansion of containership capacity. The huge excess capacity will lower the utilization of containership capacity, and the freight rate could be further decreased over time. A tighter control of cost will become more important and the price-based competition for transporting the containers could be more emphasized. In a word, this scenario of reinvesting the profits in increasing the containership capacity could make the container shipping service more commoditized over time.

In addition, if the problem of overcapacity persists and freight rates stay depressed, it is possible that carriers would focus more on chartering the containerships from the independent containership owners and operating them efficiently – rather than owning and operating the containerships simultaneously – in order to relieve themselves from the financial burden of maintaining the containerships. That is, further commoditization of the container shipping service could decouple the containership operators, or carriers, from the containership owners. This phenomenon is the current common practice in the airline industry, which share many common characteristics[50] with the container shipping industry. In the airline industry, the major airplane owners are the asset investors, such as

[50] Like the container shipping industry, the current airline industry, particularly the passenger transportation industry, is also a high fixed cost, network based, and highly commoditized industry.

GE Capital, which just own the airplanes for the financial purpose only, and most of the airline carriers charter the airplanes from the investors and operate the airplanes to provide the transportation service more cheaply. Therefore, like the airline industry, if the container shipping service continues to be commoditized by the accelerated expansion of containership capacity due to the LSO and e-business, the carriers' strategy of owning the containerships could be potentially changed and the role of asset investors could be more important in the container shipping industry. At the same time such an approach could allow carriers to drop uneconomical routes when the ship leases expired. In conclusion, the first scenario will force carriers to become more efficient containership operators in order to survive the highly commoditized competitive environments.

Meanwhile, the second scenario of potential structural change by the LSO and e-business is to reinvest the improved profits in developing the carriers' LSO capability further, rather than in expanding the containership capacity. In other words, this scenario means that carriers would try to become the logistics service provider, as opposed to being just the efficient containership operators in the first scenario. This choice could possibly improve the carriers' profitability further because the increased carriers' LSO capability helps to generate additional revenue from the logistics service as proven in the simulation results. However, to be more profitable by focusing more on the LSO, the external factors, which potentially impact the profitability from the LSO, must be closely examined in implementing this strategy. In particular, the intermediaries' competitive response of increasing their own LSO capability, which is identified as a critical factor determining the carriers' profitability from the sensitivity analysis (see Table 8-15), might be influential to determining the potential improvement of the carriers' profitability from this second scenario.

Besides the potential improvement of profitability, the second scenario could potentially restructure the container shipping industry in such a way that the basic business model of carriers changes from the container-transporting service providers to the logistics management providers. It is therefore highly expected that carriers' new focus on the logistics service in the second scenario will ignite a new front of competition between carriers and intermediaries in the container shipping industry. Particularly, a recent strategic trend of intermediaries[51] to become a subsidiary of large logistics management service providers, such as UPS and Federal Express, could produce the direct competition between these large logistics management service providers and carriers, who would try to develop the logistics service to shippers. In other words, the container shipping service could become more and more a part of larger logistics management initiative, such as supply chain management, and carriers should prepare themselves for a new competitive playing field where they have less experience.

This change of carriers' business focus, however, could pose a huge strategic question to carriers – could carriers successfully remodel themselves as logistics service providers? This task would be by no means an easy job for carriers, who have traditionally been focusing on transporting containers from port to port (or door to door), rather than managing the overall logistics for shippers. In order to be competitive logistics service providers, carriers should re-evaluate the current business relationships, develop a new capability of efficient logistics management service, and reorganize the internal business structures. These are the challenging tasks for carriers, and carriers should overcome the huge risks associated with transforming themselves for the new playing field successfully.

In summary, whatever the carriers' choice would be in reinvesting the improved profits from the LSO and e-business, either expanding the containership capacity or developing the LSO capability further, both choices are expected to derive tough business environments for carriers – therefore, carriers should make a strategic decision depending on their current strengths and weaknesses. If carriers continue to expand their containership capacity with the improved profits, they should be more efficient container-transporting service providers than they have been, and survive the more harshly commoditized competitive environments. Carriers should also develop new strategic relationships with asset investors, who might enter into the container shipping industry as containership owners. Meanwhile, although the option of focusing more on the logistics service could improve the carriers' profitability, carriers should carefully remodel

[51] For example, one of large ocean freight forwarders, Fritz, became a subsidiary of UPS in 2002.

themselves to be successful logistics service providers. Table 8-16 summarizes the potential structural changes in the container shipping industry depending on the carriers' choice of where to invest the improved profits from the LSO and e-business.

Table 8-16 Summary of Potential Structural Changes from the LSO and e-Business

Scenario 1 – Reinvesting in Capacity	Scenario 2 – Reinvesting in LSO
• Further commoditization • Huge excess capacity • Freight rate could be further decreased • Possible decoupling of the containership operators from the containership owners like in the airline industry	• Possible further improvement of the carriers' profitability • Intermediaries' competitive response will be influential • Potential restructuring of the container shipping industry • However, could carriers be successfully remodel themselves as logistics service providers?

8.4.7 Importance of Smart Expansion of Containership Capacity

Realizing that there are two strategic choices of investment and that neither choice is easy to implement, the scenario analysis is then performed to understand the impacts of each strategic choice. In other words, the optimistic and pessimistic scenarios for each strategic choice are developed and tested with the integrated model. The critical parameters, which are identified from the sensitivity analysis, are changed to develop the optimistic and pessimistic scenarios. In conclusion, the scenario analysis shows that, whatever the carriers' strategic choice may be, it is recommended that carriers expand the containership capacity more wisely and conservatively to be more profitable – i.e., a smart expansion of containership capacity is needed for the industry to be successful. The supporting evidence of this analysis is explained in the following.

Because the first strategic choice is to reinvest the improved profits in expanding the containership capacity, it is necessary to identify the critical parameters for improving the carriers' profitability in the supply-and-demand dynamics. A sensitivity analysis for the supply-and-demand dynamics is therefore performed – i.e., the sensitivity of the future base case, in which carriers continue to focus on transporting the containers without developing the logistics service, to a set of important parameters are tested.

As same as the sensitivity analysis for developing the LSO explained in 8.4.2, the cumulative unit profit of carriers is selected as the main indicator of performance, and the parameters, which are highly uncertain and are expected to be sensitive to the system's performance, are chosen for this sensitivity analysis.[52] The analysis identifies two critical parameters that substantially impact the carriers' cumulative profits: "planning horizon" and "reference utilization."

The planning horizon is the number of years that carriers consider when they estimate the desired containership capacity in the future, and the reference utilization is the target utilization on which carriers decide to increase or decrease the freight rate and invest in new containership capacity.[53] The sensitivity analysis demonstrates that the shorter the planning horizon and the higher the reference utilization, the better the carriers' profitability. In other words, if carriers consider a shorter time frame in the future when ordering the containerships, it would provide better profitability because it could reduce the speculative capacity ordering and limit the fast increase of the containership capacity, thereby increasing the utilization and the carriers' profitability. In addition, if the reference utilization becomes higher, the freight rate could be lower in the short term, which prevents carriers from expanding the containership capacity fast, so that the long-term profitability of carriers would rather increase over time. In summary, the effective control of expanding the containership capacity should help carriers improve their long-term profitability.

[52] The detailed information on the sensitivity analysis for the supply-and-demand dynamics is provided in the Appendix.
[53] The detailed description of these parameters can be found in Table 6-3 and Table 6-7 in Chapter 6.

Based on the critical parameters for the supply-and-demand dynamics, it is now possible to develop the optimistic and pessimistic scenarios and test the model behaviors for each scenario. For the first strategic choice of carriers, or reinvesting the improved profits from the LSO in expanding the containership capacity, the optimistic and pessimistic scenarios can be developed using the two critical parameters identified above as follows (see Table 8-17).

Table 8-17 The Optimistic and Pessimistic Scenario for the First Strategic Choice – "Expanding the Containership Capacity"

Optimistic Scenario - 1	Carriers will reduce the planning horizon for ordering new containerships by 25% - i.e., the planning horizon decreases from 14years to 11 years. This is possible by active fortification of the carriers' alliances, which can collectively add or withdraw the containership capacity in the market. In addition, the potential increase of asset players, who just own the containerships to generate profits by leasing them to carriers, will also help carriers reduce the planning horizon. Meanwhile, by pooling the containership capacity through the alliance, carriers can increase the reference utilization by 10%, or from 75% to 83%, which is the level in the mid 1990s.
Pessimistic Scenario - 1	Utilizing the improved profits from the LSO, each carrier would continue to expand the containership capacity actively, which renders carriers to increase the planning horizon by 25% from 14 years to 18 years. The improved carriers' profits from LSO, the cultural difference and geographic distribution of carriers, limit the improvement of the carriers' alliances; therefore, each carrier further increases the investment in new containership capacity individually. In addition, this active expansion of containership capacity will increase the impact of economy of scale by deploying larger containership, helping carriers reduce the reference utilization by 10% from 75% to 67.5%.

By the same token, the optimistic and pessimistic scenarios can be imagined for the second strategic choice of carriers – i.e., reinvesting the improved profits from LSO in developing the LSO further – by considering the critical parameters identified from the sensitivity analysis (see Figure 8-36 and Table 8-15). The first nine critical parameters in Figure 8-36 are used to perform the scenario analysis. Table 8-18 describes the optimistic and pessimistic scenarios for the second strategic choice of carriers, and Table 8-19 presents the values of the critical parameters corresponding to the optimistic and pessimistic scenarios. Among the critical parameters in Table 8-19, the nonlinear relationships are assumed to change ±10% from the base values while the remaining parameters are set to vary ±25% from the base values, in order to ensure the reality of each parameter.

Table 8-18 The Optimistic and Pessimistic Scenario for the Second Strategic Choice – "Further Developing the LSO Capability"

Optimistic Scenario - 2	The e-business is successfully diffused in the container shipping industry faster than the diffusion of EDI, thanks to the greater benefits from e-business and the low adoption cost of e-business, than those of EDI. Accordingly, carriers can further reduce the overall cost as the diffusion rate of e-business increases. In addition, carriers would hire additional salesforce for the logistics service more cautiously and cost-sensitively so that the cost of hiring additional salesforce is effectively controlled. Moreover, carriers would change their LSO commission level more frequently to reflect the market conditions. Finally, the intermediaries' LSO capability is expected to improve slower than the base case due to their financial constraints.
Pessimistic Scenario - 2	The e-business is diffused in the container shipping industry slower than the diffusion of EDI, because of the low standardization process and the organizational strains in adopting e-business. As such, the cost savings from the e-business is rather elusive and limited. In addition, carriers are overly excessive in hiring additional salesforce for developing the LSO to increase the unit cost more than expected. Furthermore, carriers' LSO commission level is changed infrequently due to the slow decision-making process. Finally, the intermediaries improve their LSO capability much faster than expected in order to counter the carriers' improving logistics service.

Table 8-19 The Values of the Critical Parameters of the Optimistic and Pessimistic Scenario for the Second Strategic Choice

PARAMETER	Base Value (MX-1)	Simulation Value: Optimistic Scenario – 2	Simulation Value: Pessimistic Scenario - 2	Comments
Effect of Relative Competitive Advantage on Attractiveness	TAB - Relative Competitive Advantage on Attractiveness *	0.9	1.1	10% Change of Value
Effect of e-Biz Benefits on Attractiveness	TAB - eBiz Benefits on Attractiveness *	1.1	0.9	
Effect of e-Biz Diffusion on Carriers Cost	TAB - eBiz Diffusion on Cost *	1.1	0.9	
Effect of Carriers LSO on Attractiveness of Carriers Service	TAB - Carriers LSO on Attractiveness of Carriers Service *	1.1	0.9	
Time to Change Carriers Commission	1 Years	0.75	1.25	25% Change of Value
Initial Development Rate of Intermediaries LSO	0.07 Fraction/Year	0.0525	0.0875	
Hiring Increase Rate	0.5 Dimensionless	0.375	0.625	
Contact Rate	11 Fraction/Year	13.75	8.25	
Cost Sensitivity to Relative Salesforce	0.08 Dimensionless	0.06	0.1	

(*) There are the table functions representing each nonlinear relationship respectively.

Figure 8-40 presents the simulation results of the scenario analysis for the first strategic choice of carriers – reinvesting the improved profits in expanding the containership capacity. Overall, the simulation results confirm that, if carriers could manage to expand the containership capacity in a wiser and conservative way, the payoff might be substantial in the long term. The optimistic scenario-1, in which carriers expand the containership capacity more wisely and conservatively, provides higher profitability than the mixed integration strategy and the future base case. The main reason for the improved profitability in the optimistic scenario-1 is that the shorter planning horizon and the higher reference utilization make the containership capacity increase slower, thereby increasing the utilization faster and improving the freight rate. Therefore, the better revenue from the higher freight rate can increase the carriers' long-term profitability. Meanwhile, the pessimistic scenario-1 generates lower profitability than the mixed integration strategy. Moreover, the utilization in the pessimistic scenario-1 is far lower than that of the mixed integration strategy, because carriers in the pessimistic scenario-1 are supposed to expand their containership capacity aggressively utilizing the improved profits from the logistics service. However, the profitability in the pessimistic scenario-1 is still higher than the future base case because the revenue from the logistics service can provide additional profits to carriers.

In addition, the scenario analysis for the second strategic choice of carriers – further developing the carriers' LSO capability – is shown in Figure 8-41. Similar to the scenario analysis for the first strategic choice, the optimistic scenario-2 presents higher long-term profitability of carriers than the mixed integration strategy and the future base case, while the pessimistic scenario-2 provides lower long-term profitability of carriers than the mixed integration strategy. Also, the improved revenue from the logistics service allows the pessimistic scenario-2 to maintain still higher profitability than the future base case. However, the improved profitability in the optimistic scenario-2 lowers the utilization substantially, mainly because carriers in the second strategic choice let the investment decision on the containership capacity be the same as in the past, which makes containership capacity increase faster due to the improved profits from the LSO. In fact, the utilization trend for the optimistic scenario-2 is as bad as that of the pessimistic scenario-1. Accordingly, the freight rate in the optimistic scenario-2 decreases faster due to the lowering utilization trend, further commoditizing the container shipping service. In summary, although the further development of carriers' LSO capability ensures the improved long-term profitability of carriers – even in the pessimistic scenario – than the future base case, the containership service itself will be further commoditized over time as carriers focus more on the logistics service without improving the traditional supply-and-demand dynamics in the container shipping industry.

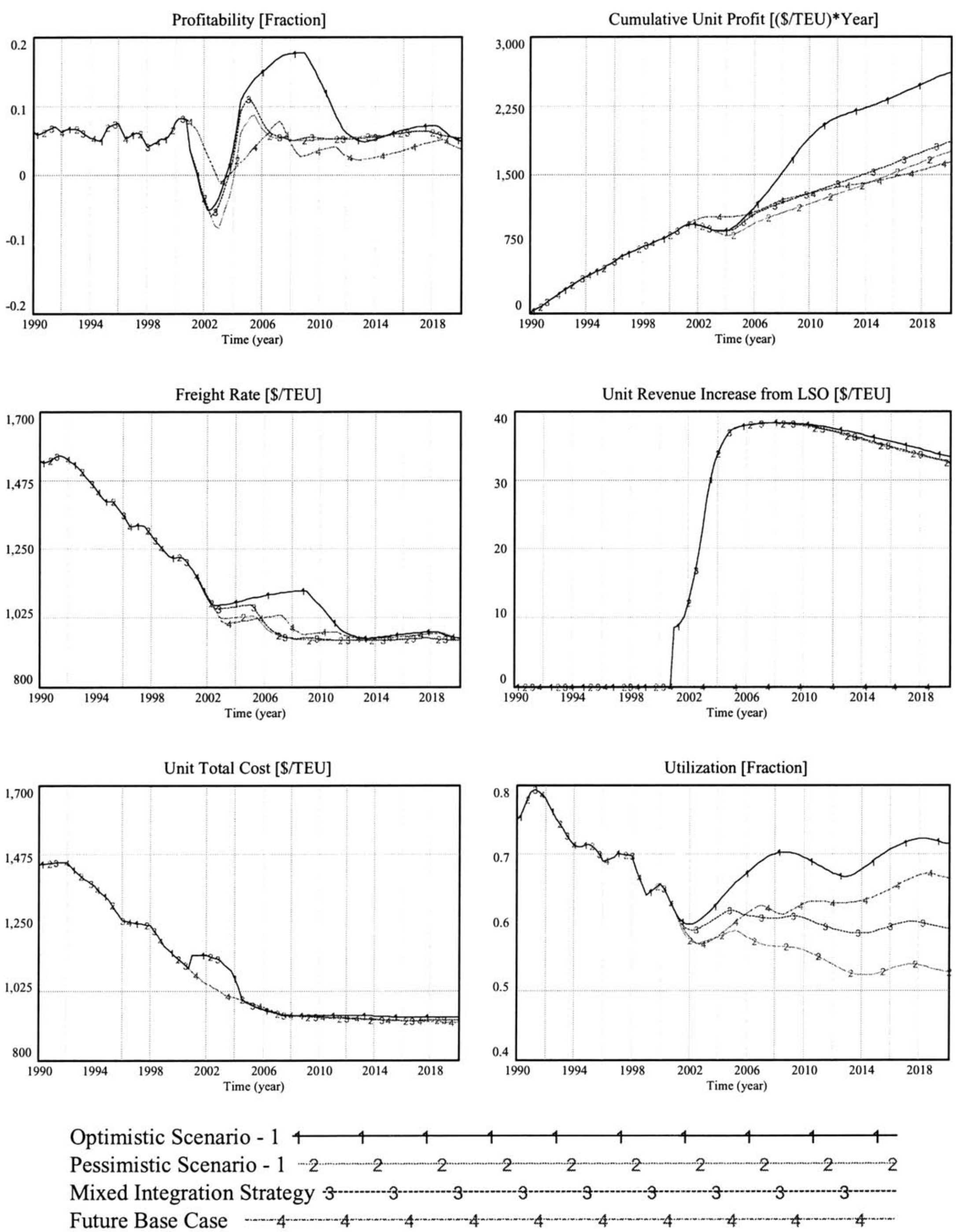


Figure 8-40 The Scenario Analysis for the First Strategic Choice of Carriers

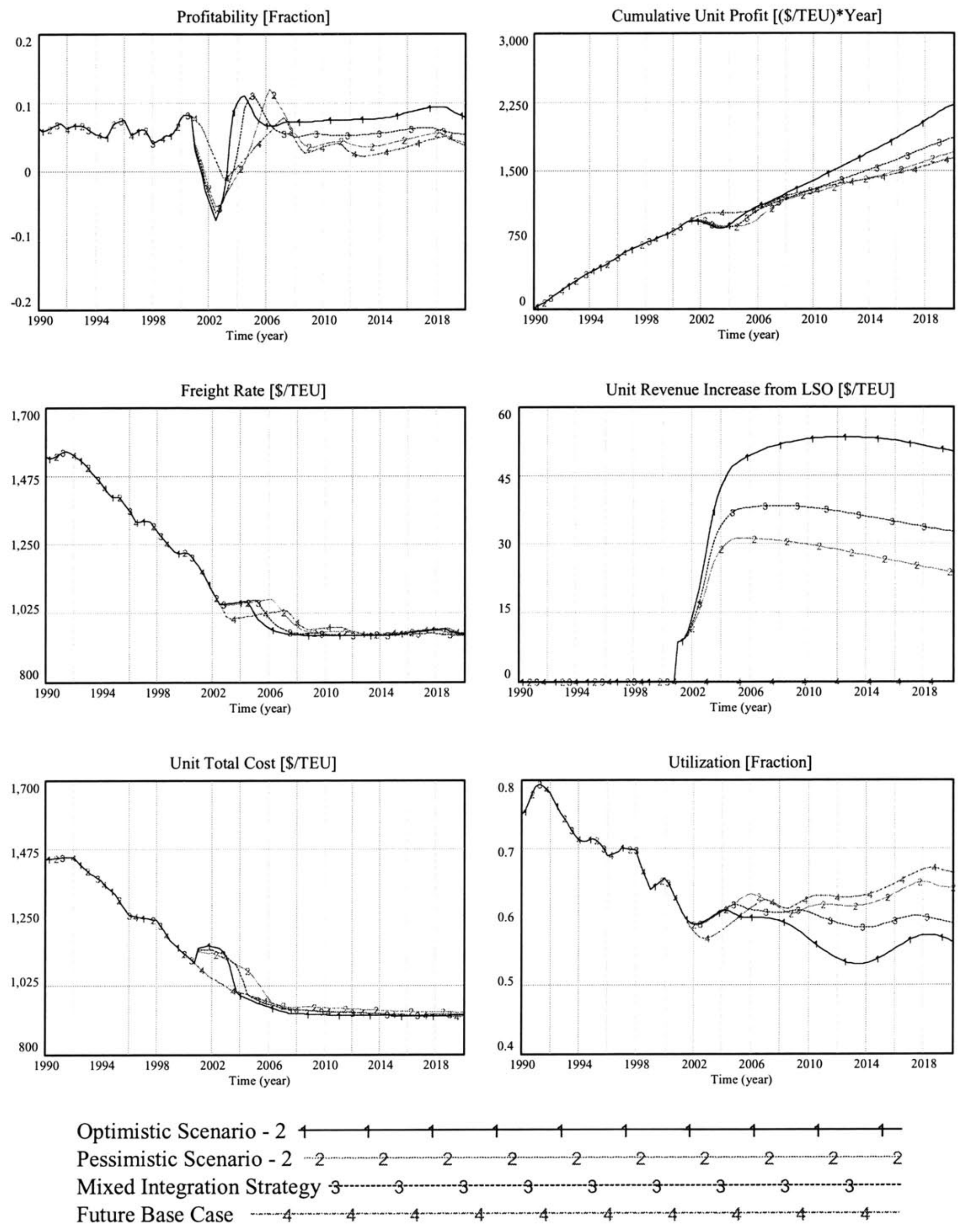


Figure 8-41 The Scenario Analysis for the Second Strategic Choice of Carriers

Next, in order to compare the two optimistic scenarios, the simulation results of the optimistic scenario-1 and the optimistic scenario-2 are shown together in Figure 8-42. The simulation results demonstrate that the optimistic scenario-1, despite the higher unit cost, generates better long-term profitability of carriers than the optimistic scenario-2. The main reason for this is the higher utilization in the optimistic scenario-1, which drives the higher freight rate and provides better profitability to carriers. Furthermore, because the overall percentage of the LSO revenue in total carriers' revenue is relatively low and the revenue from freight rate is still substantial even in cases of offering the logistics service, the optimistic scenario-1, which deals with the revenue from freight rate, could provide more profits than the optimistic scenario-2, which is the best case in offering the logistics service. Therefore, the conservative approach of expanding the containership capacity utilizing the improved profits from the LSO could provide better long-term payoff than focusing only on developing the LSO without considering the traditional supply-and-demand dynamics.

Then, the next challenge is how carriers could coordinate the LSO improvement and the expansion of containership capacity. In other words, given that the conservative approach of expanding the containership capacity utilizing the improved profits from the LSO helps carriers increase the profitability further, the best choice of carriers might be to implement the strategy of smart expansion of containership capacity while continuously improving the logistics service to shippers. In order to test this best choice of carriers, the optimistic scenario-3 is developed and simulated as follows (Table 8-20).

In the optimistic scenario-3, carriers are supposed to improve their LSO capability as they do in the optimistic scenario-2, while, at the same time, implementing a new strategy of conservatively expanding the containership capacity – i.e., "cutting the order of containership capacity in half when the utilization is below 63%." This new strategy of expanding the containership capacity is based on the reasoning that smart carriers would reduce the order rate of containership capacity substantially when the utilization of containership capacity is very low. In other words, if carriers have higher profitability from the LSO while the utilization of containership capacity is very low, a smart choice of carriers might be to retain the improved profits without investing further in the containership capacity and to wait until the utilization could pick up. In this way, carriers could prevent the fast increase of containership capacity triggered by the improved profits from the LSO, thereby maintaining higher utilization and freight rate of the container shipping service.

Table 8-20 The Description of Optimistic Scenario-3

Optimistic Scenario - 3	**In order to improve the logistics service:** The e-business is successfully diffused in the container shipping industry faster than the diffusion of EDI, thanks to the greater benefits from e-business and the lower adoption cost of e-business, than those of EDI. Accordingly, carriers can further reduce the overall cost as the diffusion rate of e-business increases. In addition, carriers would hire additional salesforce for the logistics service more cautiously and cost-sensitively so that the cost of hiring additional salesforce is effectively controlled. Moreover, carriers would change their LSO commission level more frequently to reflect the market conditions. Finally, the intermediaries' LSO capability is expected to improve slower than the base case due to their financial constraints. **At the same time, in order to expand the containership capacity conservatively:** Carriers cut the order of containership capacity in half when the utilization of containership capacity is below 63%.

Figure 8-43 compares the simulation results of three optimistic scenarios with the mixed integration strategy and the future base case. The optimistic scenario-3, which both improves the logistics service and controls the expansion of containership capacity conservatively, provides the most desirable outcomes to carriers: better freight rate due to the improved and less cyclical utilization, additional revenue from the LSO, lower unit total cost structure, and thereby better and sustainable profitability of carriers. Therefore, the optimistic scenario-3 could delay the commoditization of the container shipping service through the smart expansion of containership capacity while successfully generating additional profits from the logistics service.

Summarizing the scenario analysis above, the effective and smart control of expanding the containership capacity is more critical to improving the carriers' profitability and delaying the commoditization of container shipping service than just focusing more on developing the logistics service – i.e., whatever the carriers' choice may be, carriers should try to expand the containership capacity more wisely and conservatively to be more profitable.

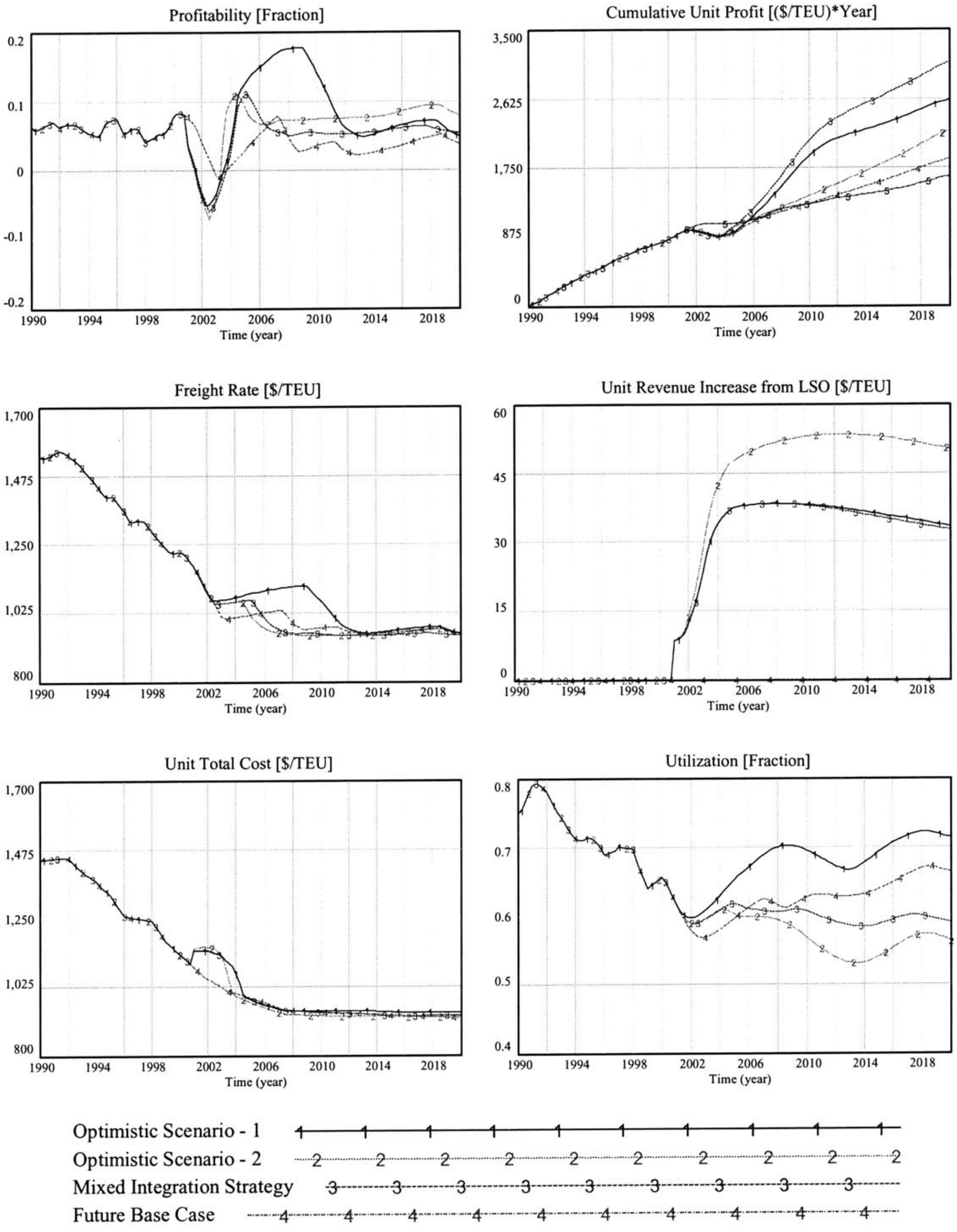


Figure 8-42 Comparison of the Optimistic Scenarios-1 and the Optimistic Scenario-2

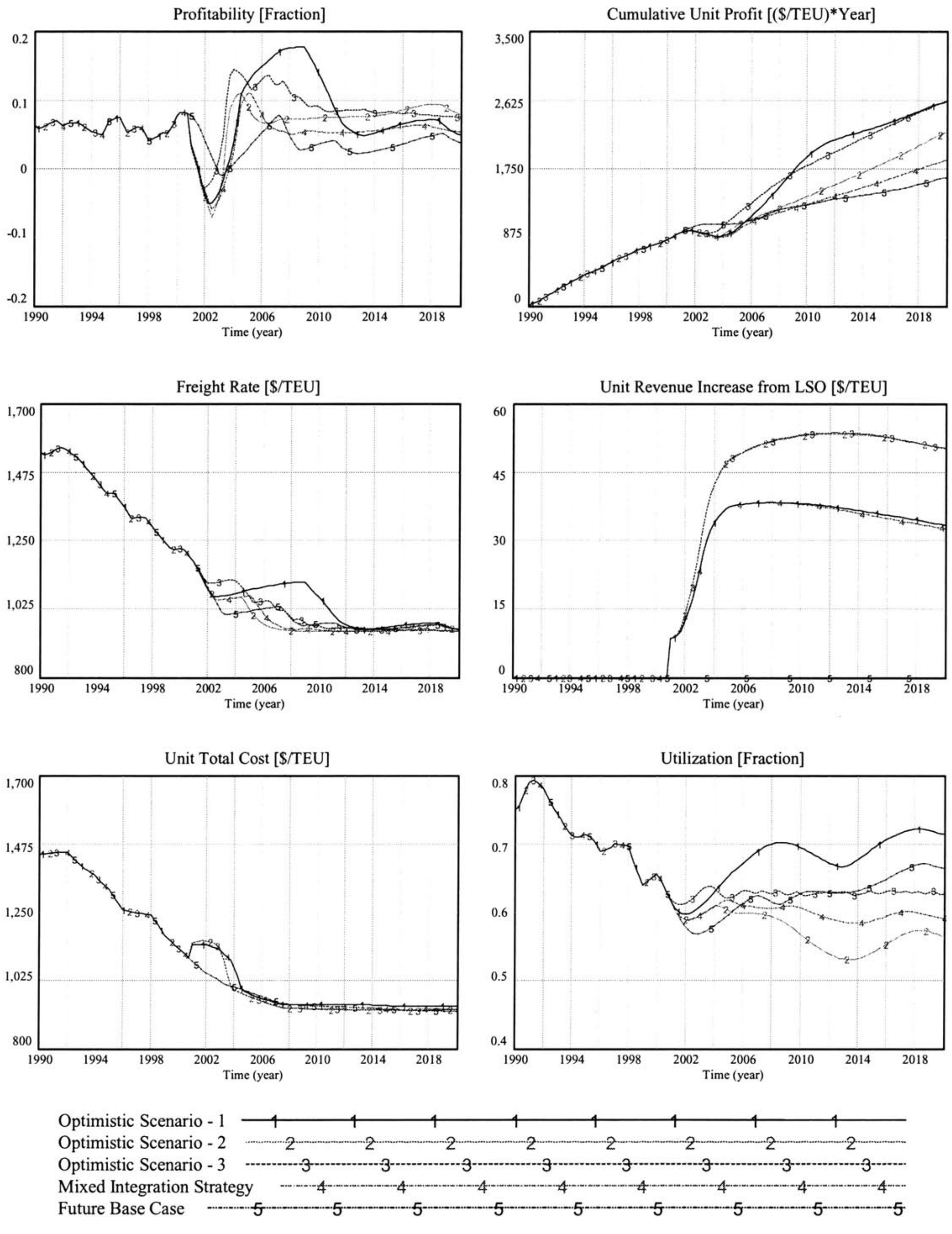


Figure 8-43 Comparison of the Three Optimistic Scenarios

8.5 Findings on the Commoditization of the Logistics Service Offering

Every new innovation or service is commoditized over time, as the container shipping service has been and will be commoditized substantially. The logistics service offering, which will be a new innovation in the container shipping industry, cannot be an exception. The LSO will be commoditized as it becomes more widely accepted by carriers and shippers. Then, the questions regarding the commoditization of LSO are how LSO will be commoditized, how long it will take, and how to respond to this commoditization process of LSO.

In this respect, this section discusses the findings on the commoditization of LSO. Three findings are derived by closely reviewing the behaviors of LSO dynamics in the integrated model and the historical technological innovations in the container shipping industry as shown in Chapter 3 and 4. First, the commoditization cycle of new innovation in the container shipping industry is identified from the LSO dynamics in section 8.5.1. Then, a notable characteristic of the commoditization cycle – i.e., longer time frame of the commoditization cycle – in the container shipping industry is discussed in section 8.5.2. Finally, section 8.5.3 recommends the "business portfolio strategy" for better profitability from the innovation in the container shipping industry.

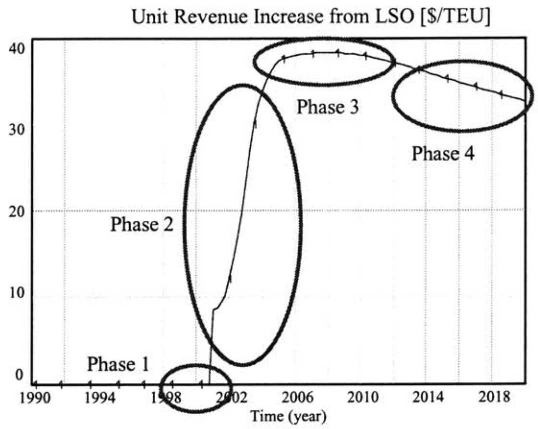
8.5.1 Commoditization Cycle of New Innovation in the CSI

A close review of the historical technological innovations in the CSI and the simulation results of the LSO in the integrated model present the commoditization cycle of new innovation in the CSI. The commoditization cycle can be divided into four phases depending on the behaviors of revenue and profitability of the new innovation (see Table 8-21).

Table 8-21 Commoditization Cycle of New Innovation in the Container Shipping Industry

- **Phase 1 – "Introduction of New Innovation"**
  - Slow increase of revenue
  - Lower profitability due to the early investment in the innovation
- **Phase 2 – "Development of the Market"**
  - Fast increase of revenue
  - Substantial increase of profitability from the new service
- **Phase 3 – "Saturation of the Market"**
  - Flattening of the revenue
  - Reaching the maximum and stable profitability
- **Phase 4 – "Waning of the Market"**
  - Decreasing of the revenue
  - Declining of the profitability

In the first phase of the "introduction of new innovation," a new innovation or service is newly introduced into the industry and is beginning to be accepted by the industry. The revenue from the new innovation increases slowly in this phase and the profitability of the new innovation is also very low, sometimes negative, due to the early investment in the innovation. After experiencing the early adoption process, the market of the new innovation starts to develop so that the revenue from the innovation increases fast and the profitability from the new service improves substantially (Phase 2). Then, the market developed from the new innovation becomes saturated over time in phase 3. The revenue from the innovation is flattening and the profitability, reaching the maximum point, is stabilizing afterwards. Finally, the innovation will be further commoditized and start to wane over time. The revenue from the innovation decreases substantially and the profitability of the innovation declines fast.



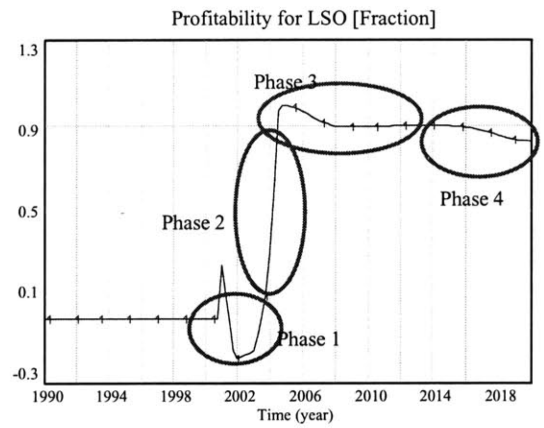


Figure 8-44 Commoditization Cycle of the Logistics Service Offering [54]

The simulation results of the LSO in the integrated model confirm the commoditization cycle of new innovation in the container shipping industry (see Figure 8-44). The revenue and profitability of the LSO show that, after undergoing the early slow increase of revenue and the loss making, both revenue and profitability increase substantially. Then, the revenue and profitability reach the saturated point and begin to slowly decline over time.

8.5.2 Longer Time Frame of the Commoditization Cycle in the CSI

One notable characteristic of the commoditization process of LSO is that the LSO is expected to be commoditized over a long period of time. In fact, Figure 8-44 shows that it takes about 15 years for the LSO innovation to reach the phase 4 of the commoditization cycle. In addition, the analysis of historical technological innovations in Chapter 3 and 4 – e.g., containerization, intermodalism, the double stack train system, and the EDI – also

[54] The profitability of LSO is unusually high at some points in the graph. The reason for this is that, due to the limited data available regarding the cost of offering the LSO, the profitability of LSO cannot be precisely tracked in the integrated model. In addition, only the combined effect of developing the LSO on the overall cost structure of carriers is calculated in the model. Therefore, the profitability of LSO in Figure 8-44 has to be estimated separately from the model, which makes the profitability of LSO higher than the normal business environment. However, the graph clearly shows the characteristics of the commoditization cycle of new innovation.

confirms that the technological innovations in the CSI have normally taken more than 10 years to be matured.

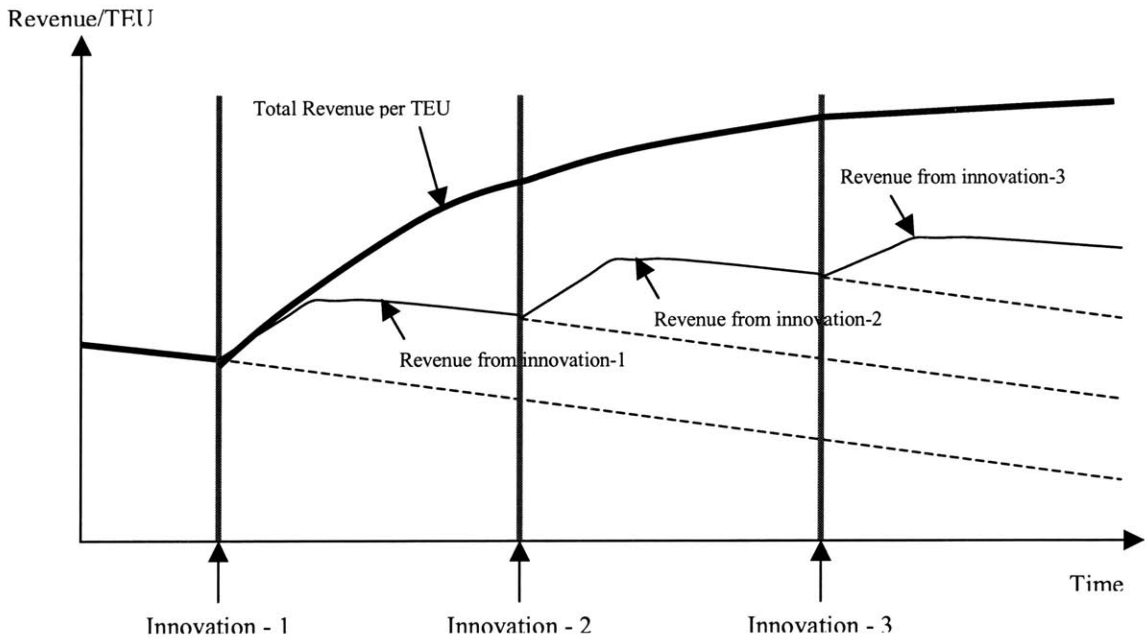
Several reasons might delay the commoditization process of the innovation in the CSI. First, the fast increase of the container shipping demand has prevented the new innovation or technology from being accepted fast. In other words, the container shipping demand, which has been increased at a rate of about 8% per year for the past 20 years, has been large enough to allow the current players and the potential competitors in the container shipping industry to generate sufficient profits without being pressured to implement new innovation or service to make additional revenue. Secondly, the container shipping industry has been traditionally technology-averse, or reluctant to adopting and developing a new technology or service. Thirdly, many different stakeholders – such as ocean carriers, truckers, railway companies, port authorities, freight forwarders, and diverse shippers, as discussed in chapter 2 – are involved in transporting the containers door to door, so that it could take longer time for a newly introduced innovation to be adopted and implemented in the container shipping industry.

8.5.3 The "Business Portfolio Strategy"

Given that any new innovation or service in the container shipping industry will eventually commoditize over time even though the commoditization takes relatively longer time, the next challenge is then what carriers should do with regard to this commoditization process of innovation? One strategy might be to develop new innovations and services continuously to maintain or improve the revenue and profitability. In other words, carriers should keep adding new services, such as logistics service, port terminal operating service, etc., through innovations over time, thereby maintaining a set of business portfolio on top of the container shipping service – i.e., the "business portfolio strategy" is recommended to carriers.

The business portfolio strategy could increase the unit revenue and profitability of carriers, just as the LSO together with the container shipping service will provide additional revenue and profits to carriers. The logic behind the business portfolio strategy can be explained as follows.

Two graphs in Figure 8-45 show the potential change of unit revenue of carriers if they successfully adopt a series of new innovations on top of the traditional container shipping service. Without any innovation or in the pre-innovation stage, the revenue per TEU will continuously decline over time because of the commoditization of the container shipping service. However, if carriers successfully implement a new service with innovation-1 at some point, carriers can generate additional revenue from the new service, so that total revenue per TEU increases over time and carriers should maintain two different sources of revenue. Meanwhile, unless carriers introduce a new innovation after adopting the innovation-1, then the revenue from innovation-1 will also commoditize, making unit revenue decrease over time. Accordingly, the total revenue per TEU might increase at a decreasing rate over time. On the other hand, if carriers, noting the commoditization of innovation-1, find an additional new innovation-2 and subsequently implement a new service, carriers could add new revenue from innovation-2 and continue to improve the total revenue per TEU over time. At this point, carriers should effectively manage the business portfolio comprising three sources of revenue: the traditional container shipping service, the service from innovation-1, and the other service from innovation-2. In the same way, the unit revenue of carriers could further increase if carriers successfully introduce the innovation-3 afterwards. Therefore, after integrating a series of innovations on top of the container shipping service, carriers could complement the declining revenue from the container shipping service and continuously improve the total revenue per TEU over time.



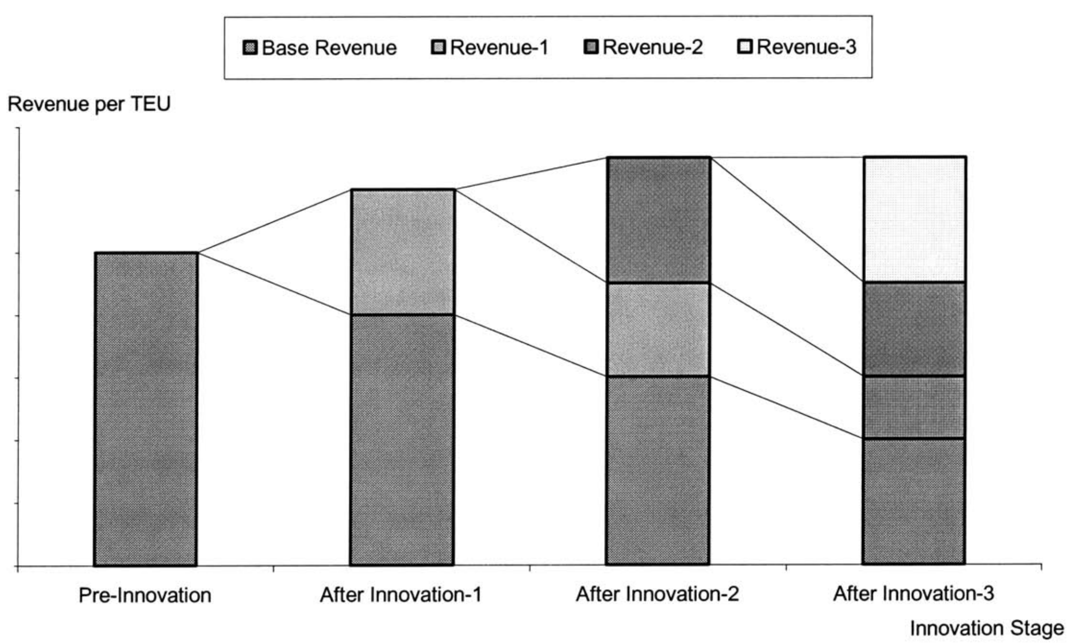


Figure 8-45 The "Business Portfolio Strategy" – Improving the Unit Revenue

Meanwhile, following the trend of increasing unit revenue, the profitability of carriers will also in general increase over time when carriers successfully implement a series of innovations (see Figure 8-46). After adopting the innovation-1, the profitability could initially decrease due to the early investment in the innovation-1, but it will increase as the additional revenue from innovation-1 outweighs the cost associated with the investment. However, as the innovation-1 becomes further commoditized over time, the profitability will rather decline slowly until carriers successively introduce the new innovation-2. By the same token, the new innovation-2 could also improve the profitability over time. Therefore, the profitability of carriers, who successfully adopt a series of innovations and manage to provide the business portfolio with the traditional container shipping service, could maintain at least the increasing trend over time despite the commoditization process.

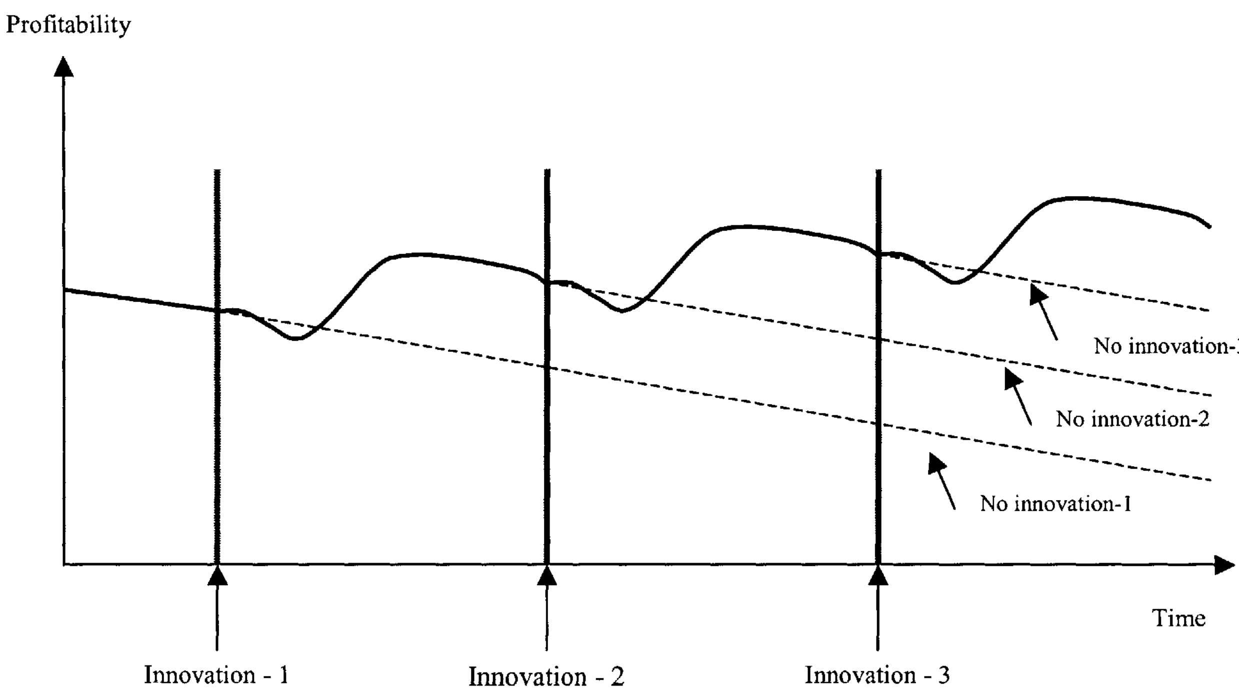


Figure 8-46 The "Business Portfolio Strategy" – Improving the Profitability

In fact, the business portfolio strategy with regard to the commoditization of new innovation or service is not at all a new idea – it has been successfully implemented in other industries. For example, IBM, who pioneered the mainframe computing business in the 1950s and 1960s, added the computer software business in the 1970s and the early 1980s after realizing the margin of selling the mainframe computers declining due to the strong competition by microcomputer makers such as Digital Equipment, thereby maintaining or improving the unit revenue and profitability. In addition, IBM also integrated the computer consulting service business in its business portfolio in the 1990s in order to supplement the further declining profit margin from the mainframe computer and software business, and it has been successful for the past 10 years. Furthermore, realizing that the computer consulting service could also become commoditized and mature eventually, IBM recently tries to develop the grid computing technology, which potentially makes the use of computing power as easy as using electrical power by plugging the cords in the electricity outlet on the wall. To summarize, IBM, which has expertise in selling the computing power, has successfully integrated the new innovations or services on top of the computer hardware business and improved, or at least maintained the revenue and profitability over time. The IBM case confirms that the business portfolio strategy, supplementing the declining revenue and profits due to the commoditization of innovation, could be helpful for carriers to counteract the commoditization trend of the container shipping service. Thus, it is strongly recommended that carriers successfully implement the business portfolio strategy over time.

8.6 Conclusions

This chapter has presented a system dynamics model for simulating the potential impacts of e-business on the container shipping industry. After estimating the future base case, where carriers do not develop any logistics service and only provide the container shipping service as usual, three strategies of developing the logistics service that carriers might take – the vertical integration, the virtual integration, and the mixed integration strategy – are modeled and tested by integrating the system dynamics models discussed in chapter 6 and chapter 7. A batch of sensitivity analysis, the Monte-Carlo simulation, and the scenario analysis are subsequently performed to better understand the model behaviors.

The analyses provide seven major findings on the potential impacts of e-business on the container shipping industry. The findings can be summarized as follows: The strategies of developing the LSO by either hiring additional salesforce or adopting e-business could improve the carriers' long-term profitability. Interestingly, the efficient cost management in offering the logistics service is more important than focusing only on the revenue increase from the logistics service. In this context, faster industry-wide diffusion of e-business, which helps carriers lower the unit cost, is crucial in improving the carriers' profitability. However, despite the improved carriers' profitability from the LSO, the container shipping service will be further commoditized over time if carriers maintain the current ways of expanding the containership capacity. Therefore, there could be two strategic choices of carriers in using the improved profits from the LSO: reinvesting them in expanding the containership capacity or in further developing the LSO capability. Each strategic choice is expected to derive the structural changes in the container shipping industry, which generates risks and challenges that carriers should endure in developing the LSO and adopting e-business. Finally, whatever the carriers' strategic decision may be, carriers are advised to expand the containership capacity more wisely and conservatively in order to be profitable in the long term.

In addition to the major findings from the simulation results, the analysis on the commoditization of LSO is also discussed in this chapter. The analysis presents that the commoditization cycle of new innovation or service in the CSI, which is in general composed of four phases, takes a relatively long period of time – at least 10 years or more. Given the commoditization of new innovation, it is highly recommended that carriers choose the "business portfolio strategy" in order to continuously improve the unit revenue and profitability despite the commoditization process.

Chapter 9 Conclusions and Future Research

9.1 Introduction

This chapter summarizes the overall findings from this research and makes the managerial recommendations for carriers in order to respond to the impacts of e-business on the containers shipping industry. Finally, potential future research areas that can be pursued on top of this research are also discussed.

9.2 Summary of Overall Findings

The purposes of this research are to understand the impacts of the e-business activities on the container shipping industry and to help carriers develop sound strategies to cope with these new challenges. In addition to the analysis of historical impacts of new technological innovations on the container shipping industry, a system dynamics model simulating the potential impacts of e-business on the container shipping industry is developed and used to derive the managerial recommendations for carriers responding to the impacts of e-business.

The analysis of historical impacts of new technological innovations is provided from chapter 2 to chapter 5. Chapter 2 first analyzes the general business dynamics in the container shipping industry and identifies the strategic challenges to carriers – one of which is to develop the logistics service offerings (LSO). In chapter 3, the historical impacts of four technological innovations – i.e., containerization, intermodalism, the double stack train system, and EDI connections – are reviewed based on the framework of technological evolution. Noticing that EDI is the most recent technological innovation in the CSI and similar to the internet technology, which is the main focus of this research, the evolution of EDI in the container shipping industry is closely discussed in chapter 4. Finally, the characteristics of six e-business models in the CSI are evaluated in chapter 5 using the three frameworks, which are originally developed in this research to analyze the technology strategies of internet-based new enterprises, concluding that the interactions between the strategic challenge of carriers, i.e., the LSO development, and the most promising e-business model, or the CTP (Collaborative Tool Provider), will be the key areas of potential impacts of e-business on the container shipping industry.

On top of the analysis on the historical impacts of new technologies on the CSI, a system dynamics modeling approach is undertaken from chapter 6 to chapter 8 in order to understand the potential impacts of e-business on the CSI more clearly. The traditional dynamics of supply-and-demand in the container shipping are modeled in chapter 6, simulating the industry dynamics in the 1990s successfully. Then, a system dynamics model for the diffusion dynamics of EDI is developed and calibrated to the 1990s' industry data in chapter 7. Finally, the integrated model simulating the potential impacts of e-business on the CSI is derived by combining the models developed in the previous chapters, and the potential impacts of e-business are closely investigated using the integrated model.

In conclusion, this research identifies several findings on the potential impacts of e-business on the CSI. These findings can be summarized as four major impacts of e-business on the container shipping industry: First, the most promising e-business model, the CTP, will be closely interacting with the logistics service offering, which is one of the strategic challenges of carriers facing these days. Second, the profitability of carriers will be improved if they successfully develop the LSO capability with e-business in a cost efficient way. Third, despite the improved profitability from the LSO and e-business, the container shipping service could be commoditized further unless changes are made to the current practice of expanding the containership capacity – or "growing fast with bigger ships." Finally, whatever the carriers' choice may be for investing the improved profits, the LSO and e-business could drive the structural changes in the container shipping industry.

9.3 Recommendations for Carriers with Regard to e-Business

Paraphrasing the findings from the simulation of integrated model, several action items can be recommended with regard to the impacts of e-business on the container shipping industry as follows (see Table 9-1):

Table 9-1 Recommended Action Items for Carriers Regarding the Impacts of e-Business

Recommendations for Carriers	Reasons
1. Developing the logistics service and adopting the e-business actively	In order to improve the carriers' long-term profitability
2. Focusing more on the efficient cost management in developing the LSO and adopting the e-business	The carriers' profitability is more sensitive to the cost of developing the LSO and e-business
3. Driving faster adoption of e-business in the CSI	The more diffusion of e-business, the more cost savings of carriers is expected; thereby, improving the carriers' long-term profitability
4. Preparing for the further commoditization of the container shipping service	The improved profits from LSO and e-business will expedite the commoditization of the container shipping service
5. Positioning themselves clearly either as containership operators or logistics service providers	In order to cope with the potential structural changes of industry due to the LSO and e-business
6. Expanding the containership capacity more wisely and conservatively	Revenue from the freight rate is still more substantial to carriers and influential to the profitability of carriers than that from the LSO
7. Continuing to add the new services on top of the container shipping service – "Business Portfolio Strategy"	In order to counter the commoditization of new innovation and to improve the profitability in the long term

9.4 Future Research Areas

The findings and limitations of this research lead to research agendas that can be addressed in the future. Two main research areas might be considered: One is to extend the system dynamics model further for the container shipping industry, and the other is to leverage the research methodologies adopted in this research to the issues in other similar industries (see Table 9-2).

The first research area, extending the system dynamics model for the container shipping industry, could have three research topics: First, the integrated model developed in this research can be further used to explore the best way of implementing the strategies recommended in this research. For example, noting that the effective control of expanding the containership capacity is crucial for the better profitability of carriers, the integrated model might be used for identifying the efficient policies to manage the expansion of containership capacity. Second, the integrated model should be further refined and developed as e-business becomes more adopted in the CSI over time. For instance, data used for the simulation must be carefully updated to reflect the changing development of the e-business market and further analysis should be carried out in the future. Third, the integrated model could be updated into a management simulator, which can be used as a learning tool for managers in the CSI to help them be familiarized with the industry dynamics.

The other research area is to apply the research methodologies used in this research to other similar industries. Three research topics can be pursued in the future: First, the three frameworks for evaluating the success potential of e-business models as discussed in chapter 5 could be used for analyzing the e-business activities in other similar industries, such as the airline industry. Second, this research has explored the interactions between the technological innovations, e.g., the internet technology, and the commoditization of traditional service, e.g., the container shipping service, in the high fixed cost industry of the CSI. The same issues could be analyzed in other industries with high fixed cost structure – for instance, the energy, the telecommunication, or the chemical industry, etc.

– can be analyzed and compared using the methodologies adopted in this research. Finally, the generic model for the supply-and-demand dynamics in the CSI as explained in chapter 6 can be augmented to simulate and analyze the supply-and-demand dynamics in other shipping industries, such as the dry bulk shipping, or the oil shipping industry, etc.

Table 9-2 The Future Research Areas

	Research Topics	Examples
Expanding the SD Model for the Container Shipping Industry	1. Tackling the issues of implementing the recommended strategies	• How to effectively control the expansion of containership capacity? • How to expedite the adoption of e-business in the CSI?
	2. Refining and developing the integrated model further	• Data updating as the e-business market develops • Adding the more realistic competitive dynamics of intermediaries
	3. Developing a management simulator to help managers in the CSI be familiarized with the industry dynamics	• "Learning-by-Simulation" training exercises
Leveraging the Methodologies to Other Similar Industries	4. Applying the three frameworks of evaluating the e-business models to the cases in other industries	• Evaluating the e-business models in the airline industry
	5. Analyzing and comparing the technological innovation and its commoditization in other high fixed cost industries	• Energy industry • Telecommunication industry • Chemical industry
	6. Developing a system dynamics model for the supply-and-demand dynamics in other shipping industries	• Dry bulk shipping industry • Oil shipping industry

Appendix

A.1 Introduction

The appendix is prepared to present the detailed simulation results of the integrated model, which are not fully covered in chapter 8. Starting with the detailed explanation on the causal loop diagram for the LSO dynamics in section A.2, the structures of integrated model except those on the supply-and-demand dynamics that are described in detail in chapter 6 are discussed in section A.3. Finally, the sensitivity analyses are explained in section A.4.

A.2 Causal Loop Diagram for the LSO Dynamics

The feedback loops for the dynamics of LSO are constructed by focusing on the factors that might affect the level of carriers' LSO capability and its interactions with carriers' profitability. Competition between intermediaries and carriers to provide the logistics service to shippers is also considered. Twelve feedback loops are expected to govern the dynamics of LSO in the container shipping industry (see Figure A.2-1 and Table A.2-1). In the following sections are presented the detailed explanations of each feedback loop for the dynamics of LSO in the container shipping industry.

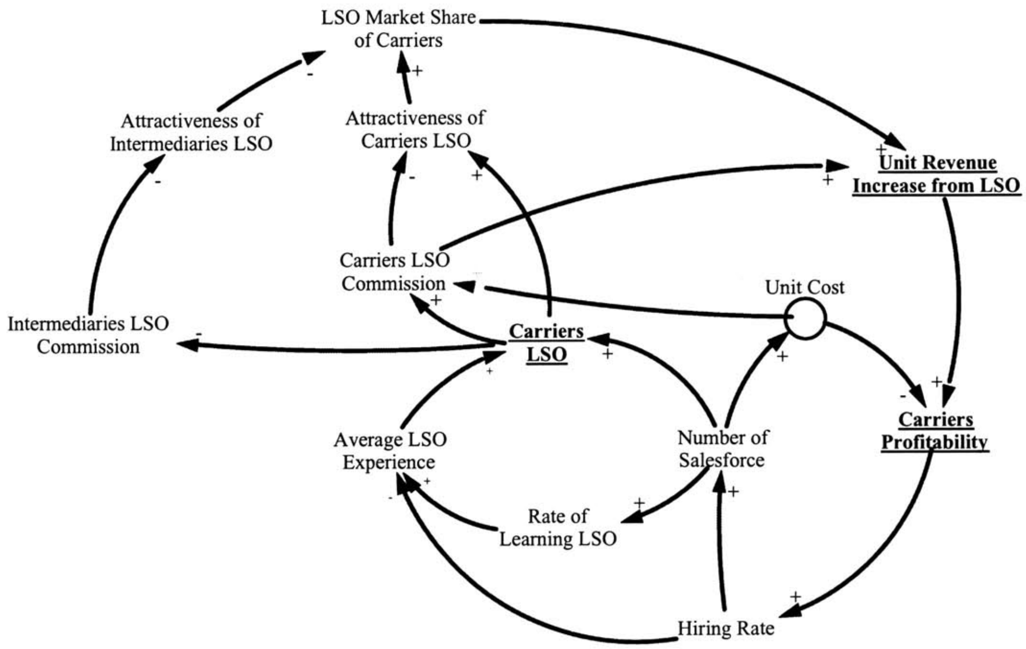


Figure A.2-1 Causal Loop Diagrams for the Dynamics of Logistics Service Offering

Table A.2-1 List of Variables in the Feedback Loops of Dynamics of LSO

Key Variables	Definition	Dimension	State Variable
Carriers LSO	The level of carriers' capability of providing logistics service measured in years of LSO experience	Year	
Average LSO Experience	The average experience of salesforce of providing LSO service	Year / People	Yes
Number of Salesforce	The number of salesforce of carriers in the container shipping industry	People	Yes
Carriers LSO Commission	The money that carriers charge per TEU for their LSO service	$ / TEU	Yes
Intermediaries LSO Commission	The money that intermediaries charge per TEU for their LSO service	$ / TEU	Yes

Key Variables	Definition	Dimension	State Variable
Rate of Learning LSO	The average rate at which salesforce gains the experience measured by "years" per year; i.e., this is the average rate of learning by the salesforce.	(Year/People)/Year	
Hiring Rate	The number of salesforce per year that carriers hire	People / year	
Carriers Profitability	The total operating margin per TEU divided by total revenue per TEU	Dimensionless	
Unit Revenue Increase from LSO	Carriers' annual additional revenue stream from LSO service, calculated by "Carriers LSO Commission" times "LSO Market Share of Carriers"	$ / TEU	
Unit Cost	The total cost of shipping a container and providing LSO, measured by dollar per TEU	$ / TEU	
LSO Market Share of Carriers	The carriers' market share in the LSO market	Dimensionless	
Attractiveness of Carriers LSO	The extent that the carriers' LSO service is attractive to shippers	Dimensionless	
Attractiveness of Intermediaries LSO	The extent that the intermediaries' LSO service is attractive to shippers	Dimensionless	

A.2.1 Reinforcing "Salesforce" Feedback Loop-1 (LSO-R1)

The first impact of improved carriers' LSO capability is the increased profitability of carriers by collecting additional revenue for providing the logistics service to shippers. The improved profitability will allow carriers to hire more salesforce that will be staffed to provide better logistics service – e.g., carriers could provide more personalized one-stop service to shippers by retaining a growing number of salesforce. More salesforce can therefore improve the carriers' LSO capability. Hence, these causal relationships become a reinforcing feedback loop (see Figure A.2-2).

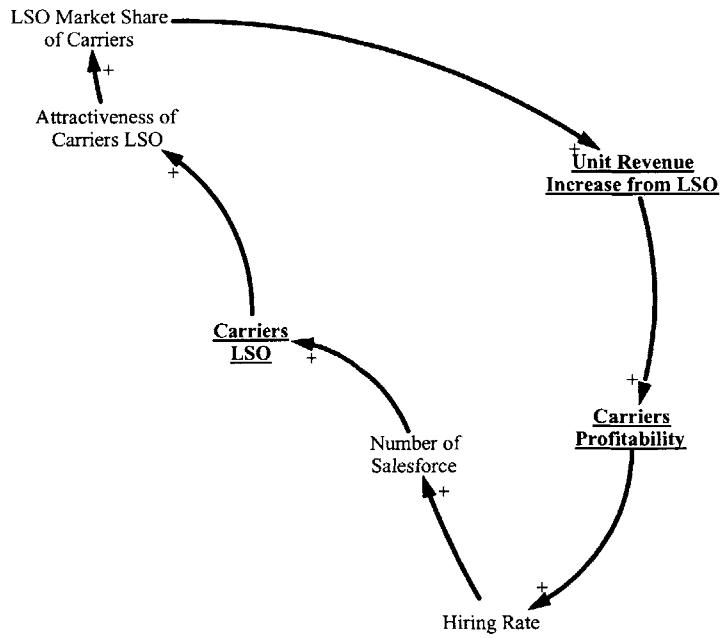


Figure A.2-2 Reinforcing "Salesforce" Feedback Loop (LSO-R1)

A.2.2 Reinforcing "LSO Experience" Feedback Loop (LSO-R2)

Carriers' LSO capability is also impacted by the average LSO experience of carriers' salesforce. As the number of salesforce increases, the average LSO experience of carriers will increase by a faster rate of learning LSO among the salesforce, so that the carriers' LSO capability will be improved. The improved carriers' LSO capability will subsequently increase the revenue and profitability of carriers, and the increased profitability will help carriers recruit more salesforce to improve the average LSO experience again. These dynamics therefore constitute another reinforcing feedback loop with regard to the carriers' LSO capability (see Figure A.2-3).

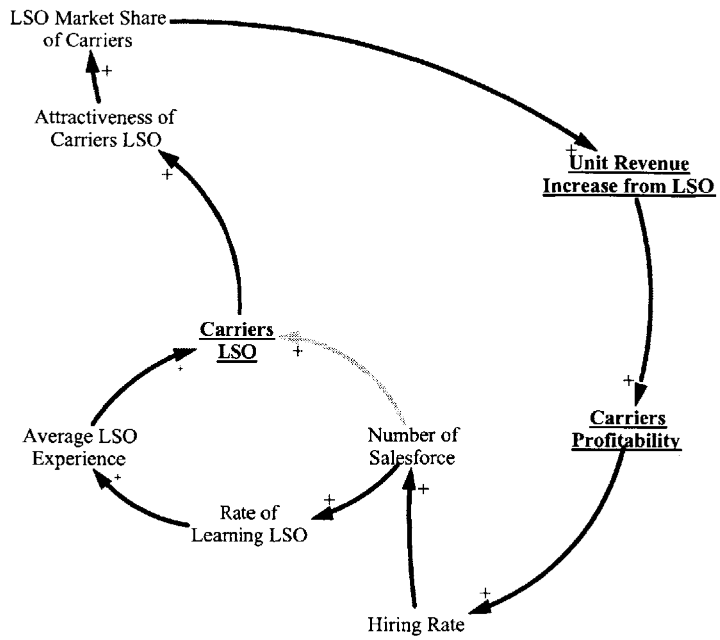


Figure A.2-3 Reinforcing "LSO Experience" Feedback Loop (LSO-R2)

A.2.3 Balancing "Diluted LSO Experience" Feedback Loop (LSO-B1)

Hiring new salesforce does not always improve the carriers' LSO capability; however, new salesforce could deteriorate the carriers' LSO capability by lowering the average LSO experience of carriers. In other words, a newly hired salesforce is generally less experienced in logistics service so that the average LSO experience will tend to be diluted due to the increased hiring rate. The decreased carriers' LSO capability will accordingly reduce the revenue and profitability of carriers, and carriers should decrease the hiring rate. Therefore, these relationships form a balancing feedback loop (see Figure A.2-4).

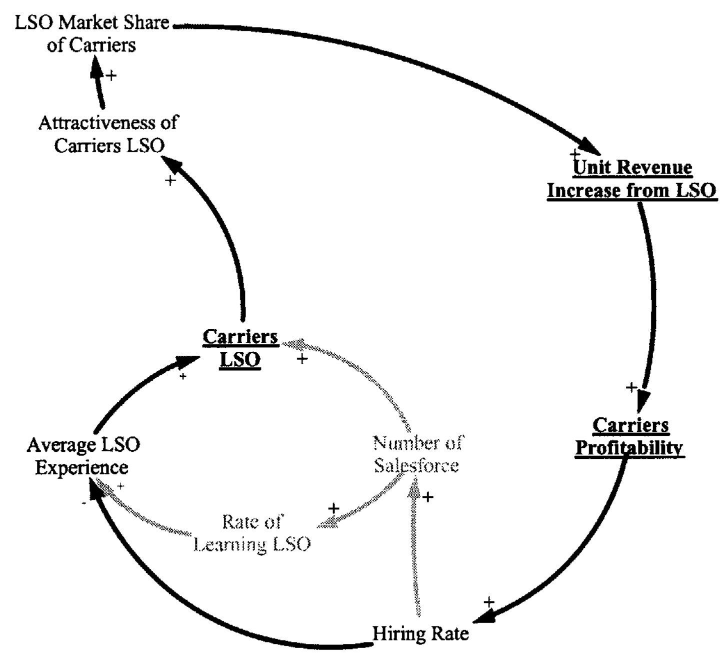


Figure A.2-4 Balancing "Diluted LSO Experience" Feedback Loop (LSO-B1)

A.2.4 Balancing "Cost" Feedback Loop (LSO-B2)

Hiring new salesforce to improve the carriers' LSO capability cannot be achieved free – Carriers must pay the cost for it. As the number of salesforce increases, the administrative cost of carriers should increase, which in turn lowers the profitability. The decreased profitability will make carriers reduce the hiring rate; then, the number of salesforce should decrease, which therefore constitutes a balancing feedback loop (see Figure A.2-5).

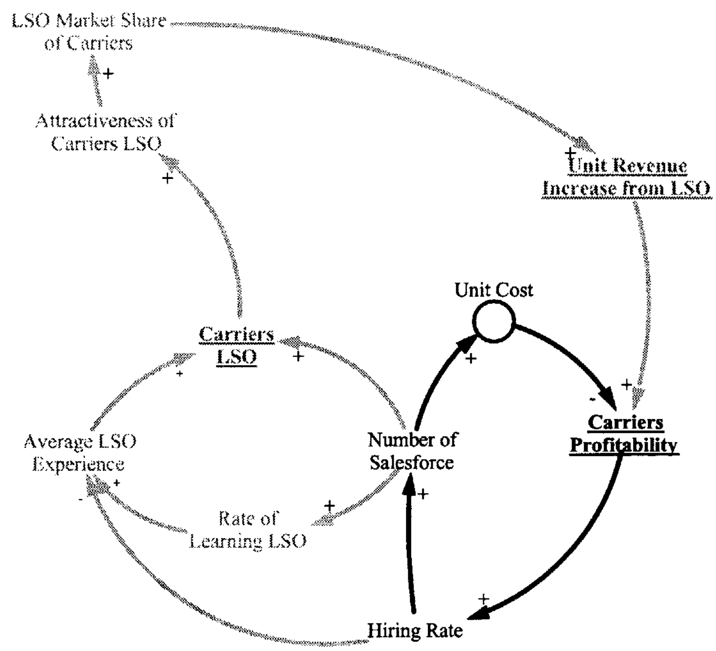


Figure A.2-5 Balancing "Cost" Feedback Loop (LSO-B2)

A.2.5 Balancing "Carriers' LSO Commission" Feedback Loop (LSO-B3)

The increased cost due to the increasing number of salesforce for improving the LSO capability of carriers also makes another balancing loop connected with the carriers' LSO commission, which is the charge that carriers receive from shippers for providing the logistics service. The increased cost will push carriers to raise the LSO commission to cover the cost associated with providing the logistics service. Because of the increased LSO commission of carriers, the attractiveness of carriers' LSO service and its market share will decrease, so that the revenue and profitability of carriers will reduce. Then, the reduced profitability will make carriers cut back the hiring rate and the number of salesforce, thereby decreasing the cost of carriers; therefore, these dynamics make a balancing feedback loop (see Figure A.2-6).

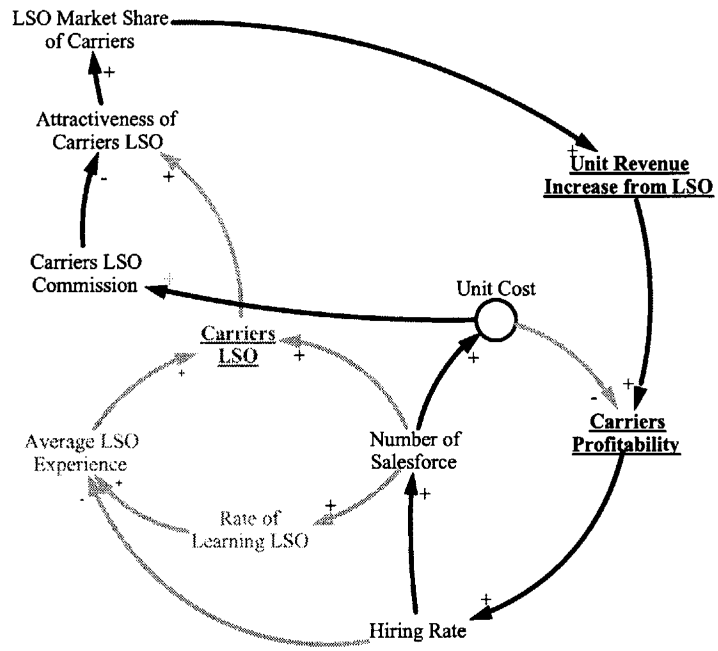


Figure A.2-6 Balancing "Carriers' LSO Commission" Feedback Loop (LSO-B3)

A.2.6 Reinforcing "Carriers' LSO Commission" Feedback Loop (LSO-R3)

In addition to the balancing feedback loop, the increased carriers' LSO commission can make a reinforcing feedback loop. The increased unit cost of carriers will increase the carriers' LSO commission, and the increased LSO commission will also increase the revenue and profitability of carriers subsequently. The increased profitability will allow carriers to hire more salesforce, so that the cots of carriers again increase. Therefore, this makes another reinforcing feedback loop (see Figure A.2-7).

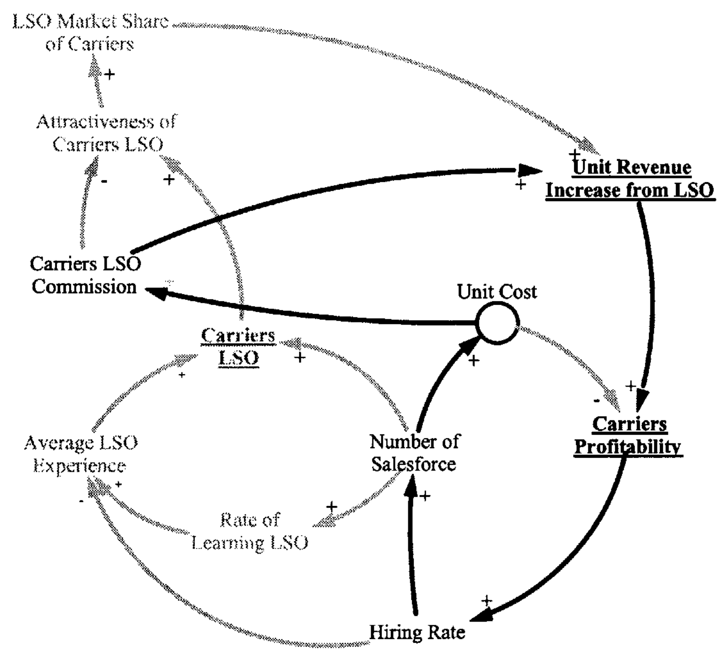


Figure A.2-7 Reinforcing "Carriers' LSO Commission" Feedback Loop (LSO-R3)

A.2.7 Balancing "Intermediaries' LSO Commission" Feedback Loop (LSO-B4)

The LSO market in the container shipping industry has been dominated by intermediaries; consequently, it is important to consider the intermediaries' competitive actions responding to the improvement of carriers' LSO capability. In this research, two variables are considered for the competitive actions of intermediaries: intermediaries' LSO commission and intermediaries' LSO capability. The former is endogenously generated in the model while the latter is exogenously input. In other words, it is assumed that intermediaries will change their LSO commission to react to the competitive challenges from carriers whereas the intermediaries' LSO capability improves regardless of the change of carriers' LSO capability. Only the intermediaries' LSO commission is therefore used to construct the feedback loops.

The improved carriers' LSO capability will force intermediaries to reduce their LSO commission to improve the attractiveness of their LSO service. Then, the LSO market share of carriers will tend to decrease because of the improved attractiveness of intermediaries' LSO service, and so do the revenue and profitability of carriers. The decreased profitability of carriers will make carriers reduce the hiring rate and the number of salesforce, so that the carriers' LSO capability will rather decrease. Therefore, these dynamics provide a balancing feedback loop (see Figure A.2-8).

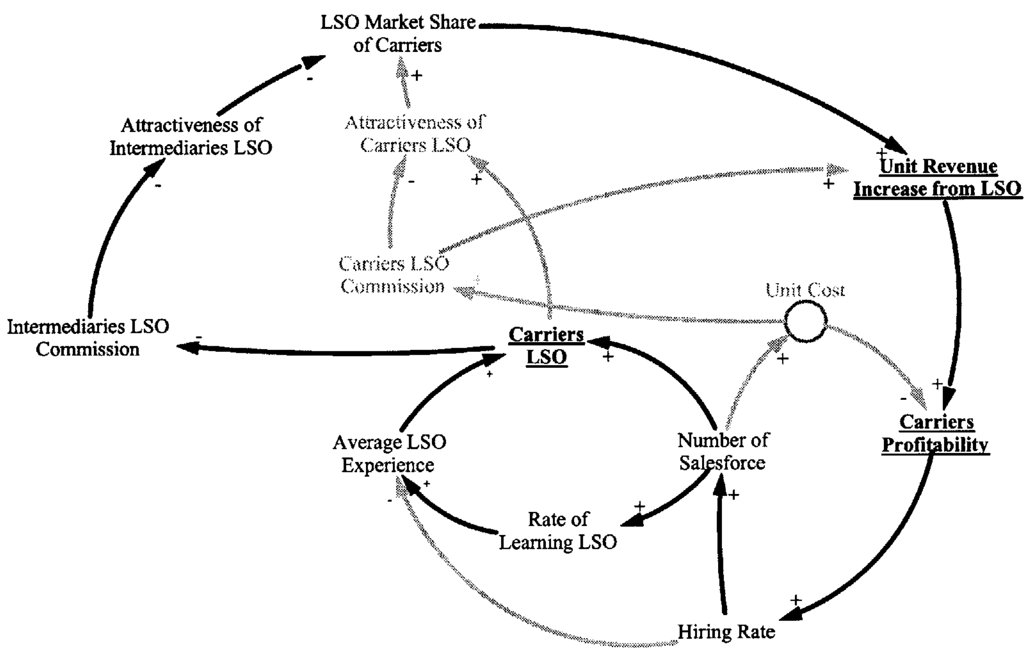


Figure A.2-8 Balancing "Intermediaries' LSO Commission" Feedback Loop (LSO-B4)

A.2.8 Reinforcing "Intermediaries' LSO Commission" Feedback Loop (LSO-R4)

The change of intermediaries' LSO commission can also make a reinforcing feedback loop. The reduced intermediaries' LSO commission responding to the improved carriers' LSO capability will eventually decrease the profitability and hiring rate of carriers because of the same relationships above. Then, the decreased hiring rate will help increase the average LSO experience of carriers by hiring less sales people who are less experienced in the logistics service. The increased average LSO experience of carriers therefore improves the carriers' LSO capability again, thereby constituting a reinforcing feedback loop (see Figure A.2-9).

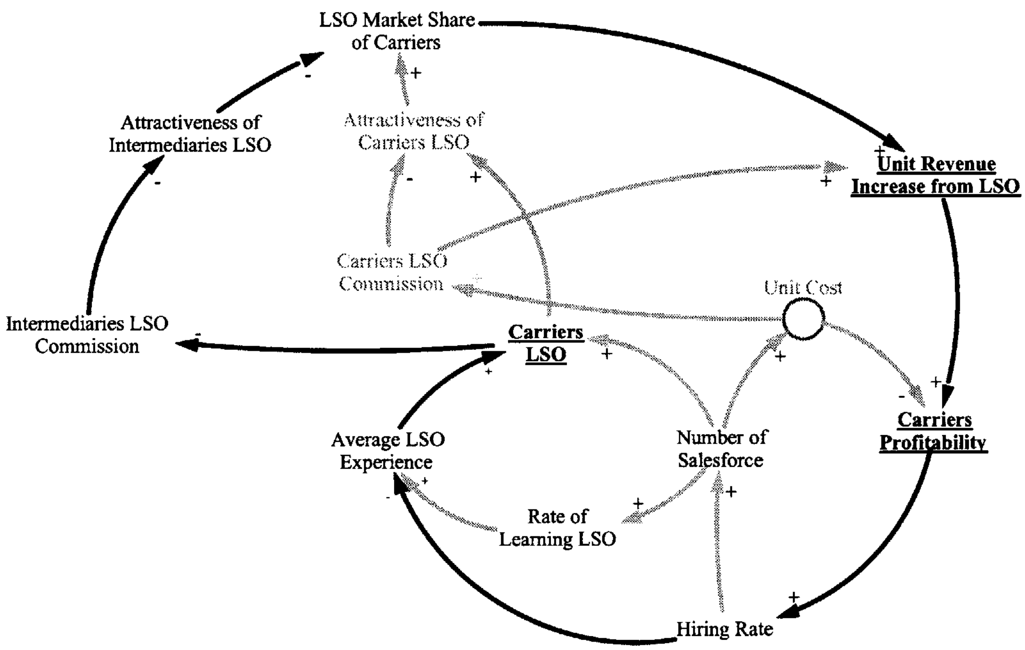


Figure A.2-9 Reinforcing "Intermediaries' LSO Commission" Feedback Loop (LSO-R4)

A.2.9 Balancing "Carriers' Commission – LSO" Feedback Loop (LSO-B5; LSO-B6)

Carriers' LSO commission can be impacted, not only by the cost to the carriers to provide the LSO service, but also by the carriers' LSO capability. As the carriers' LSO capability increases, the carriers' LSO commission will tend to increase, and vice versa. This change of carriers' LSO commission due to the change of carriers' LSO capability brings two balancing feedback loops. The first balancing loop comes from the relationship with the carriers' LSO commission and the revenue of carriers (see Figure A.2-10). Once the carriers' LSO commission increases due to the improved carriers' LSO capability, the revenue and profitability of carriers will increase accordingly, and so does the hiring rate of salesforce. The increased hiring rate in turn reduces the average LSO experience of carriers so that the carriers' LSO capability also decreases, thereby forming a balancing feedback loop.

The second balancing feedback loop comes from the dynamics of the carriers' LSO commission and the attractiveness of carriers' LSO service (see Figure A.2-11). The increased LSO commission of carriers will lower the attractiveness of carriers' LSO service and reduce the market share of carriers' LSO service. Accordingly, the revenue and profitability of carriers will decrease, and so does the number of salesforce due to the decreased hiring rate. The decreased number of salesforce will therefore reduce the carriers' LSO capability and the carriers' LSO commission. As such, these dynamics make another balancing feedback loop.

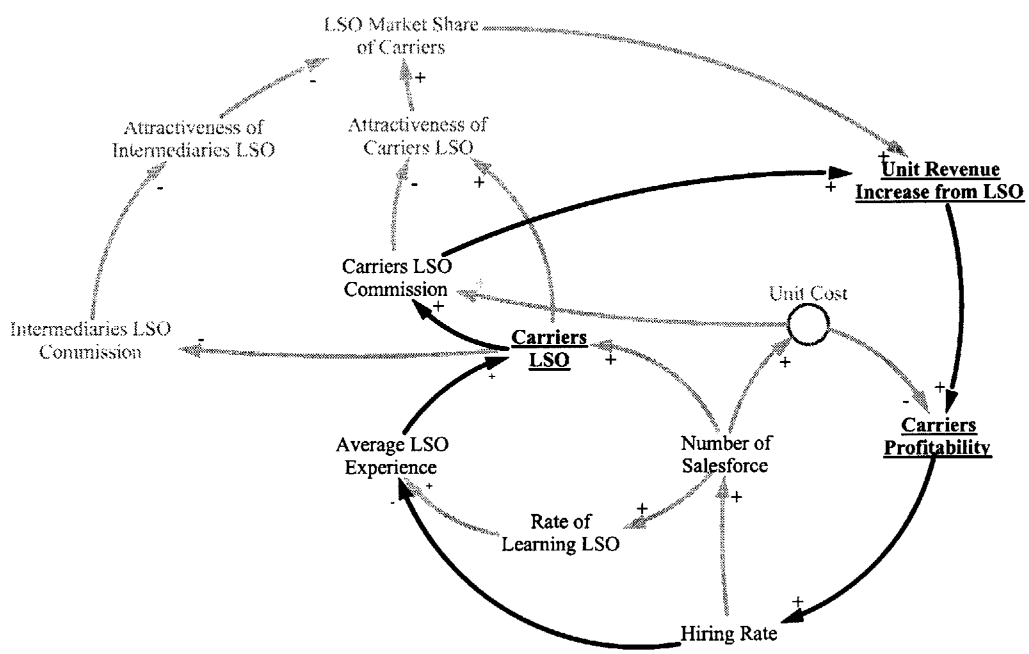


Figure A.2-10 Balancing "Carriers' Commission – LSO" Feedback Loop 1 (LSO-B5)

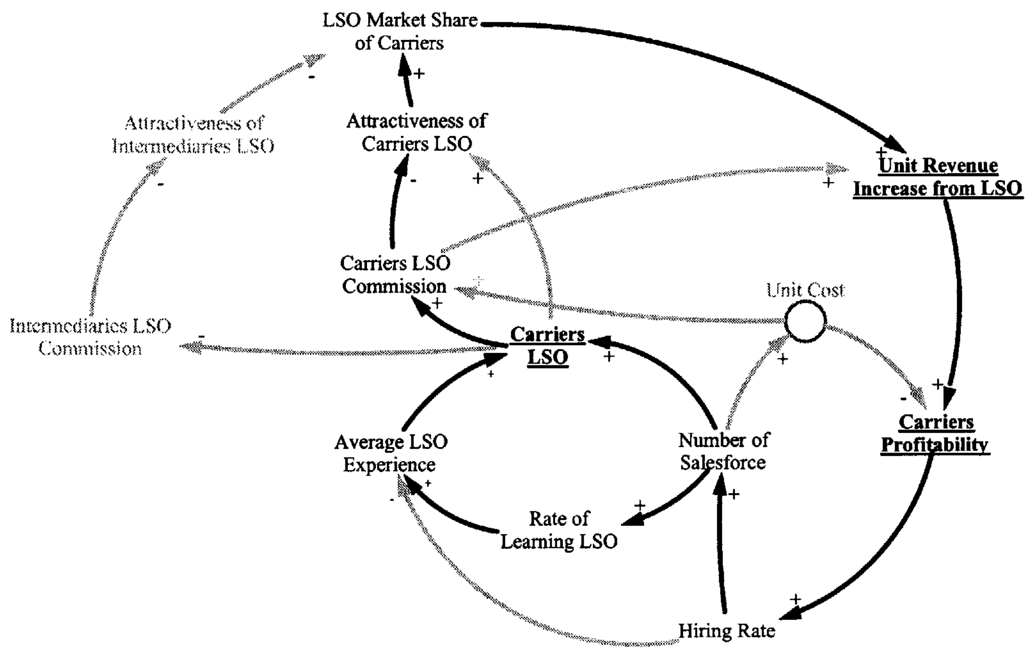


Figure A.2-11 Balancing "Carriers' Commission – LSO" Feedback Loop 2 (LSO-B6)

A.2.10 Reinforcing "Carriers' Commission – LSO" Feedback Loop (LSO-R5; LSO-R6)

Meanwhile, the relationship between the carriers' LSO capability and carriers' LSO commission brings two combinations of reinforcing feedback loops. The increasing carriers' LSO commission due to the carriers' increased LSO capability will increase the revenue and profitability of carriers, and subsequently increase the hiring rate and the number of salesforce. Then, the increased number of salesforce will again improve the carriers' LSO capability, thereby constructing a reinforcing feedback loop (see Figure A.2-12).

In addition, the linkage of the carriers' LSO commission and the attractiveness of carriers' LSO service also derives another reinforcing feedback loop (see Figure A.2-13). The improved carriers' LSO capability will increase the carriers' LSO commission, which will also decrease the attractiveness of carriers' LSO service and its market share. The decreased market share of carriers' LSO service will then reduce the revenue and profitability of carriers, and consequently the hiring rate of salesforce. The decreased hiring rate, however, will increase the average LSO experience of carriers, thereby improving the carriers' LSO capability. Therefore, these dynamics form another reinforcing feedback loop.

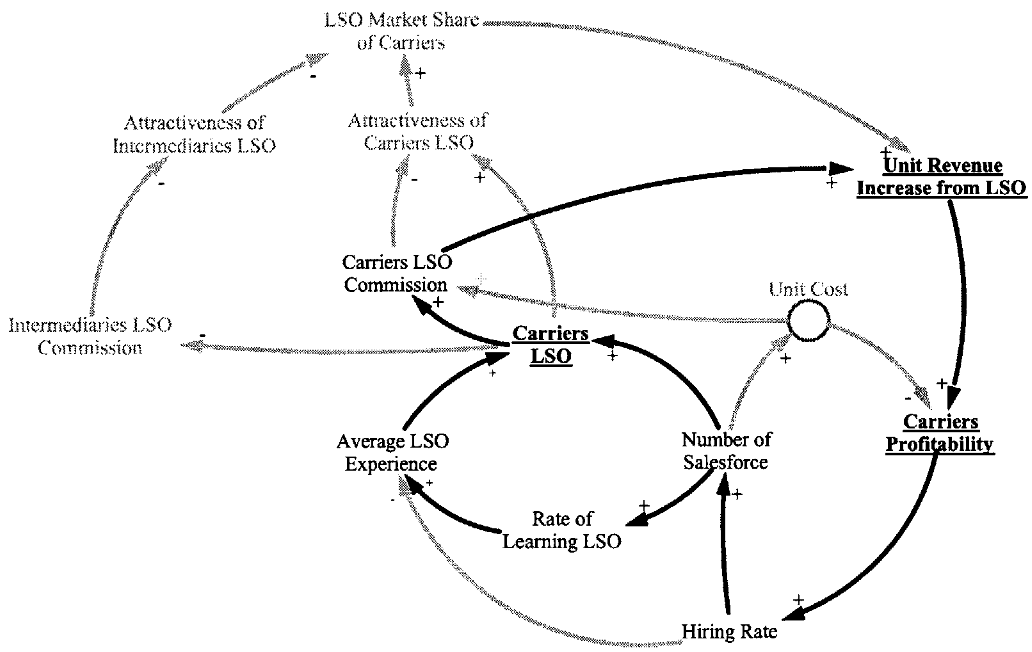


Figure A.2-12 Reinforcing "Carriers Commission - LOS" Feedback Loop 1 (LSO-R5)

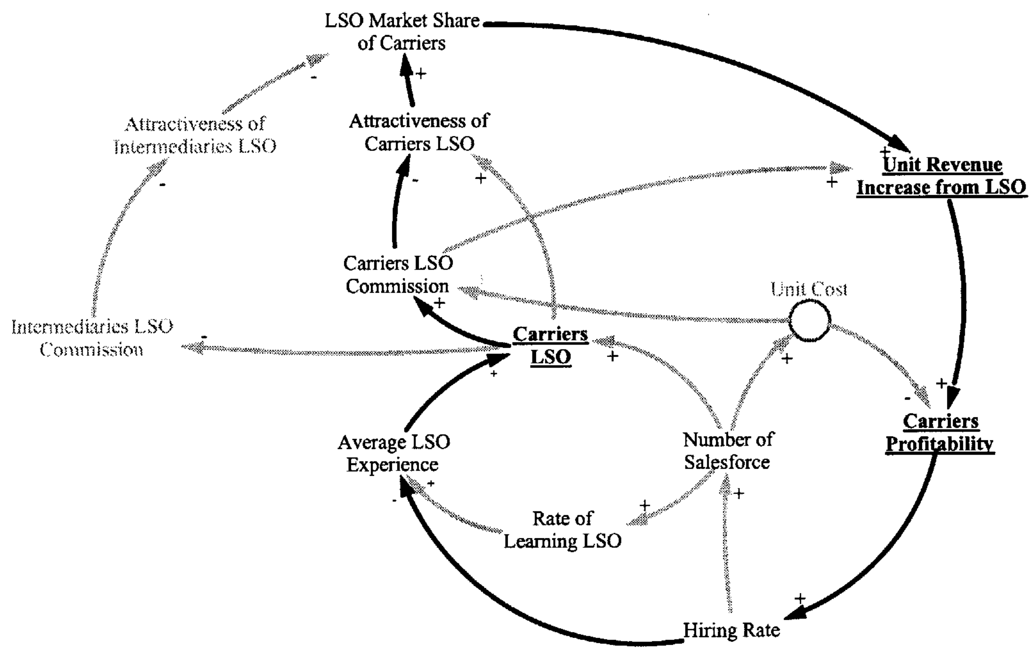


Figure A.2-13 Reinforcing "Carriers' Commission – LSO" Feedback Loop 2 (LSO-R6)

A.3 Model Structure

As explained in section 8.3.3, eight sectors regarding the dynamics of LSO and the diffusion dynamics of e-business are described in this section. Section A.3.1 and A.3.2 describe how the LSO capabilities of carriers and intermediaries are developed respectively. Since the model is constructed from the carriers' perspective, only the carriers LSO is endogenously determined while the intermediaries LSO is exogenously input. The next section represents the dynamics of changing number of salesforce in the carriers and the average experience of LSO of the salesforce over time (section A.3.3). Then, the market share sector for simulating the competition between carriers and intermediaries is explained in section A.3.4, and the dynamics of controlling the commission for the LSO service is described in the LSO commission sector (section A.3.5). A way of calculating the carriers' revenue increase from the LSO service is presented in the LSO revenue sector (section A.3.6). Finally, two sectors governing the diffusion dynamics of e-business are explained in section A.3.7 and section A.3.8.

A.3.1 Carriers LSO Sector

The carriers LSO sector models the development of the carriers' capability of providing the LSO to shippers. The carriers LSO is assumed to be the total years of salesforce's experience of providing the logistics service. In other words, the carriers' LSO is estimated by the number of salesforce multiplied by the average experience of LSO per salesforce of the carriers.

This approach is based on the previous research (Oliva, 1996) in which the production function in a high-contact service environment is best represented by a Leontief production function where the amount of output is limited by the resource with minimum availability. In general, the Leontief production function is defined as follows:

$$SC = a \min\left(L/i,\ K \right)$$

where SC = Service Capacity

a: Productivity of production factors

L: Labor

K: Capital

i: average labor intensity

Meanwhile, the logistics service in the container shipping industry, according to the service process matrix (Schmenner, 1986), can be classified as a "professional service" requiring high degree of labor intensity and high degree of interaction and customization: i.e., the quality of labor delivering the high-contact professional service is more important than other factors. Therefore, it is further assumed that, in the case of providing the logistics service to shippers, the labor is the critical factor limiting the level of service capacity. Only the labor can be used as a production factor determining the level of service capacity in the carriers' logistics service by carriers. Accordingly, the service capacity of providing the logistics service, or the carriers LSO, can be defined as follows:

$$Carriers\ LSO = aL$$

In this formulation, the productivity of production factors (a) is assumed to be the average experience of providing the logistics service because the more experienced, the more productive the labor is.

Figure A.3-1 shows the stock and flow structure for the carriers LSO sector. The main inputs to this sector from other sectors are salesforce and average experience of LSO, which are derived from the salesforce sector, and the output from this sector is the relative carriers LSO, which is the input to the market share sector. The exogenous parameters are the initial carriers LSO and the shippers' perception time of carriers LSO. The detailed equations are explained in the following.

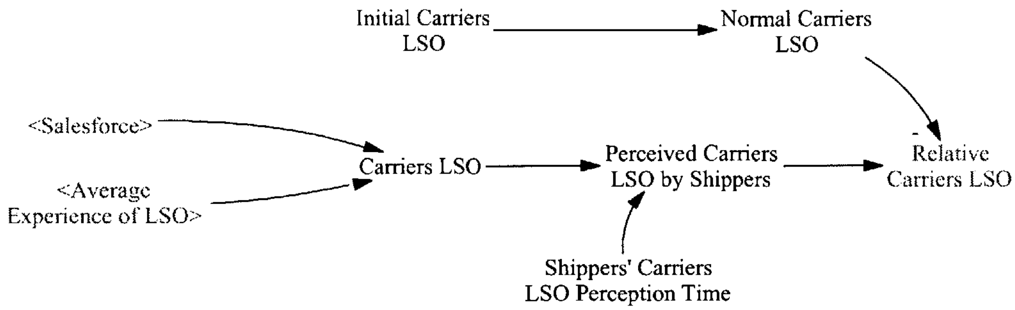


Figure A.3-1 Structure of Carriers LSO Sector

(1) Carriers LSO = Salesforce * Average Experience of LSO

(2) Normal Carriers LSO = Initial Carriers LSO

(3) Perceived Carriers LSO by Shippers = SMOOTH (Carriers LSO, Shippers' Carriers LSO Perception Time)

(4) Relative Carriers LSO = Perceived Carriers LSO by Shippers / Normal Carriers LSO

A.3.2 Intermediaries LSO Sector

The intermediaries LSO sector captures the potential development of the intermediaries' capability of providing the LSO to shippers. In this model, the competitive actions by the intermediaries to improve their LSO capability are assumed to be the exogenous variables in order to focus more on the strategic challenges of carriers. The growth rate of intermediaries' LSO capability is assumed to decay exponentially over time. Figure A.3-2 shows the structure of the intermediaries LSO sector.

The exogenous parameters to this sector include the initial intermediaries LSO, the initial development rate of intermediaries LSO, the annual decay rate of development rate of intermediaries LSO, and the shipper's perception time of intermediaries LSO. The output from this sector is the relative intermediaries LSO, which is used for the input to the market share sector. The detailed equations in the intermediaries LSO sector are shown in the following.

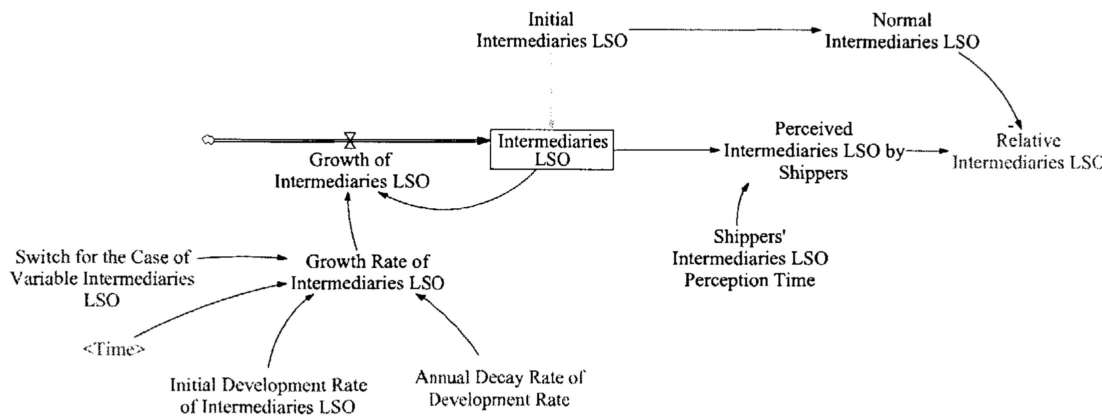


Figure A.3-2 Structure of Intermediaries LSO Sector

(5) Intermediaries LSO = INTEG (Growth of Intermediaries LSO, Initial Intermediaries LSO)

(6) Growth of Intermediaries LSO = Growth Rate of Intermediaries LSO * Intermediaries LSO

(7) Growth Rate of Intermediaries LSO = IF THEN ELSE (Time < 2001, 0, IF THEN ELSE (Switch for the Case of Variable Intermediaries LSO = 1, Initial Development Rate of Intermediaries LSO*EXP(-Annual Decay Rate of Development Rate*(Time - 2001)), 0))

(8) Perceived Intermediaries LSO by Shippers = SMOOTH (Intermediaries LSO, Shippers' Intermediaries LSO Perception Time)

(9) Normal Intermediaries LSO = Initial Intermediaries LSO

(10) Relative Intermediaries LSO = Perceived Intermediaries LSO by Shippers / Normal Intermediaries LSO

A.3.3 Salesforce Sector

The salesforce sector simulates the development of carriers' salesforce and the average experience of LSO over time. The co-flow structure (Sterman, 2000) is used for integrating the salesforce with the average experience of LSO. Figure A.3-3 presents the structure of the salesforce sector.

The input to this sector is relative profitability, which is calculated from the model for the dynamics of supply-and-demand in the container shipping industry. It is assumed that if carriers' profitability improves, carriers would hire more salesforce in order to provide better logistics service to shippers. The exogenous parameters to this sector are switch for LSO case of hiring, time to perceive and clear the hiring needs, average hiring rate, hiring increase rate for LSO, initial salesforce, time to quit or retire salesforce, average experience of LSO on new hire, initial average experience of LSO, switch for LSO case of experience by salesforce, and cost sensitivity to relative salesforce. Two table functions, "TAB – Relative Profitability on Hiring" and "TAB – Relative salesforce on Rate of Learning," are provided to control the nonlinear relationships among the variables. The output from this sector is the effect of relative salesforce on cost, which is the input to the cost sector in the model for the dynamics of supply-and-demand. The detailed equations of this sector are provided below.

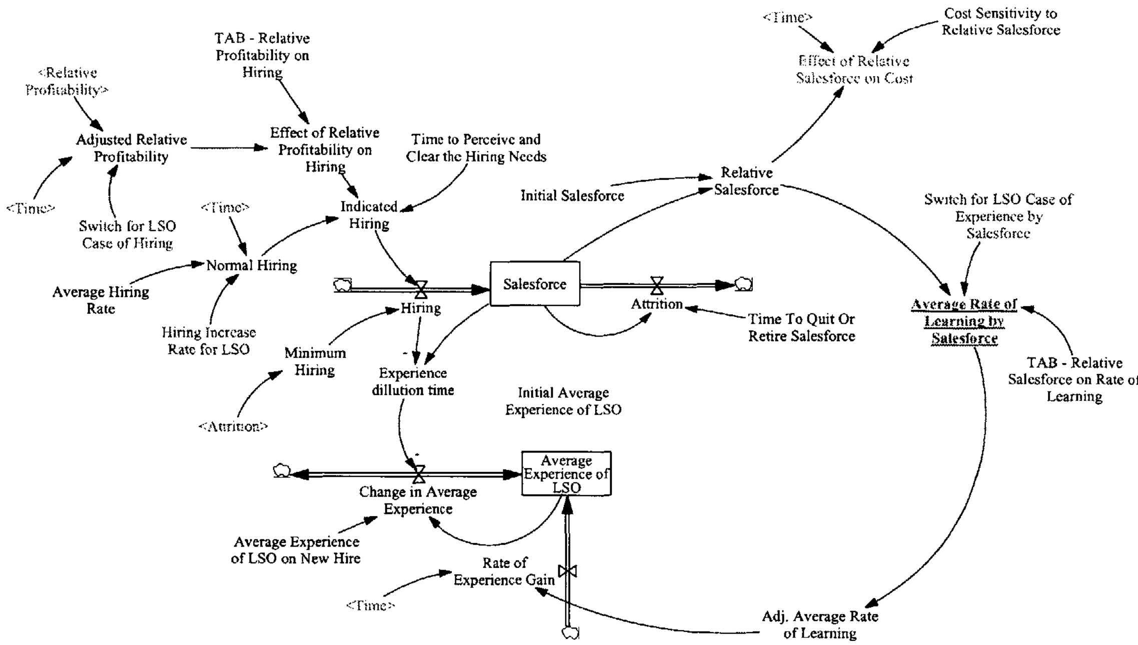


Figure A.3-3 Structure of Salesforce Sector in the LSO Dynamics

(11) Salesforce = INTEG (Hiring – Attrition, Initial Salesforce)

(12) Hiring = MAX (Minimum Hiring, Indicated Hiring)

(13) Minimum Hiring = Attrition

(14) Indicated Hiring = SMOOTH (Normal Hiring*Effect of Relative Profitability on Hiring, Time to Perceive and Clear the Hiring Needs)

(15) Normal Hiring = IF THEN ELSE (Time < 2001, Average Hiring Rate, Average Hiring Rate*(1+Hiring Increase Rate for LSO))

(16) Effect of Relative Profitability on Hiring = "TAB - Relative Profitability on Hiring"(Adjusted Relative Profitability)

(17) Attrition = Salesforce/Time To Quit Or Retire Salesforce

(18) Average Experience of LSO = INTEG (Change in Average Experience + Rate of Experience Gain, Initial Average Experience of LSO)

(19) Change in Average Experience = (Average Experience of LSO on New Hire - Average Experience of LSO) / Experience dilution time

(20) Experience Dilution Time = Salesforce / Hiring

(21) Rate of Experience Gain = IF THEN ELSE (Time < 2001, 0, "Adj. Average Rate of Learning")

(22) Adj. Average Rate of Learning = Average Rate of Learning by Salesforce

(23) Average Rate of Learning by Salesforce = Switch for LSO Case of Experience by Salesforce*"TAB - Relative Salesforce on Rate of Learning"(Relative Salesforce)

(24) Relative Salesforce = Salesforce / Initial Salesforce

(25) Effect of Relative Salesforce on Cost = IF THEN ELSE (Time < 2001, 0, Cost Sensitivity to Relative Salesforce * (Relative Salesforce – 1))

A.3.4 Market Share Sector

The market share sector determines the market share of carriers and intermediaries for the logistics service. It is assumed that the market share is determined by the attractiveness of the logistics service provided by the carriers and intermediaries and the attractiveness is controlled by the level of LSO capability and the level of commission charged for providing the logistics service. Figure A.3-4 shows the structure of the market share sector.

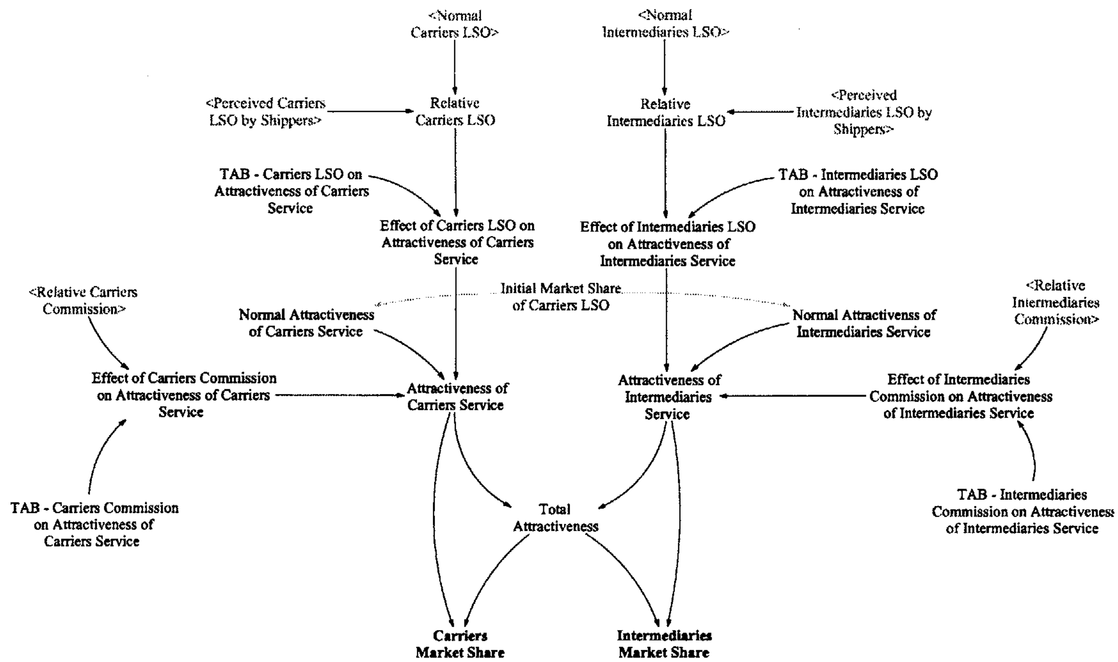


Figure A.3-4 Structure of Market Share Sector

The main inputs to this sector are the relative LSOs of carriers and intermediaries, which are estimated from the carriers LSO sector and the intermediaries LSO sector respectively, and the relative commissions of carriers and intermediaries, which are calculated from the LSO commission sector. The exogenous parameter to this sector is the initial market share of carriers LSO. The output from this sector is the carriers market share, which is used for estimating the unit revenue increase from the LSO in the LSO revenue sector. The nonlinear relationships connecting the relative LSO, the relative commission, and the attractiveness of LSO service are described by the four table functions: "TAB – Carriers LSO on Attractiveness of Carriers Service," "TAB – Intermediaries LSO on Attractiveness of Intermediaries Service," "TAB – Carriers Commission on Attractiveness of Carriers Service," and "TAB – Intermediaries Commission on Attractiveness of Intermediaries Service." The detailed equations are explained in the following

(26) Carriers Market Share = Attractiveness of Carriers Service / Total Attractiveness

(27) Intermediaries Market Share = Attractiveness of Intermediaries Service / Total Attractiveness

(28) Total Attractiveness = Attractiveness of Carriers Service + Attractiveness of Intermediaries Service

(29) Attractiveness of Carriers Service = Normal Attractiveness of Carriers Service*Effect of Carriers LSO on Attractiveness of Carriers Service*Effect of Carriers Commission on Attractiveness of Carriers Service

(30) Attractiveness of Intermediaries Service = Normal Attractiveness of Intermediaries Service * Effect of Intermediaries LSO on Attractiveness of Intermediaries Service*Effect of Intermediaries Commission on Attractiveness of Intermediaries Service

(31) Normal Attractiveness of Carriers Service = 100*Initial Market Share of Carriers LSO

(32) Effect of Carriers LSO on Attractiveness of Carriers Service = "TAB - Carriers LSO on Attractiveness of Carriers Service"(Relative Carriers LSO)

(33) Effect of Carriers Commission on Attractiveness of Carriers Service = "TAB - Carriers Commission on Attractiveness of Carriers Service"(Relative Carriers Commission)

(34) Normal Attractiveness of Intermediaries Service = 100 * (1 - Initial Market Share of Carriers LSO)

(35) Effect of Intermediaries LSO on Attractiveness of Intermediaries Service = "TAB - Intermediaries LSO on Attractiveness of Intermediaries Service"(Relative Intermediaries LSO)

(36) Effect of Intermediaries Commission on Attractiveness of Intermediaries Service = "TAB - Intermediaries Commission on Attractiveness of Intermediaries Service"(Relative Intermediaries Commission)

A.3.5 LSO Commission Sector

The LSO commission sector captures the level of commission charged by carriers and intermediaries for providing the logistics service. It is formulated that relative improvement of the LSO service by carriers and intermediaries determines the level of LSO commission. Figure A.3-5 presents the structure of the LSO commission sector.

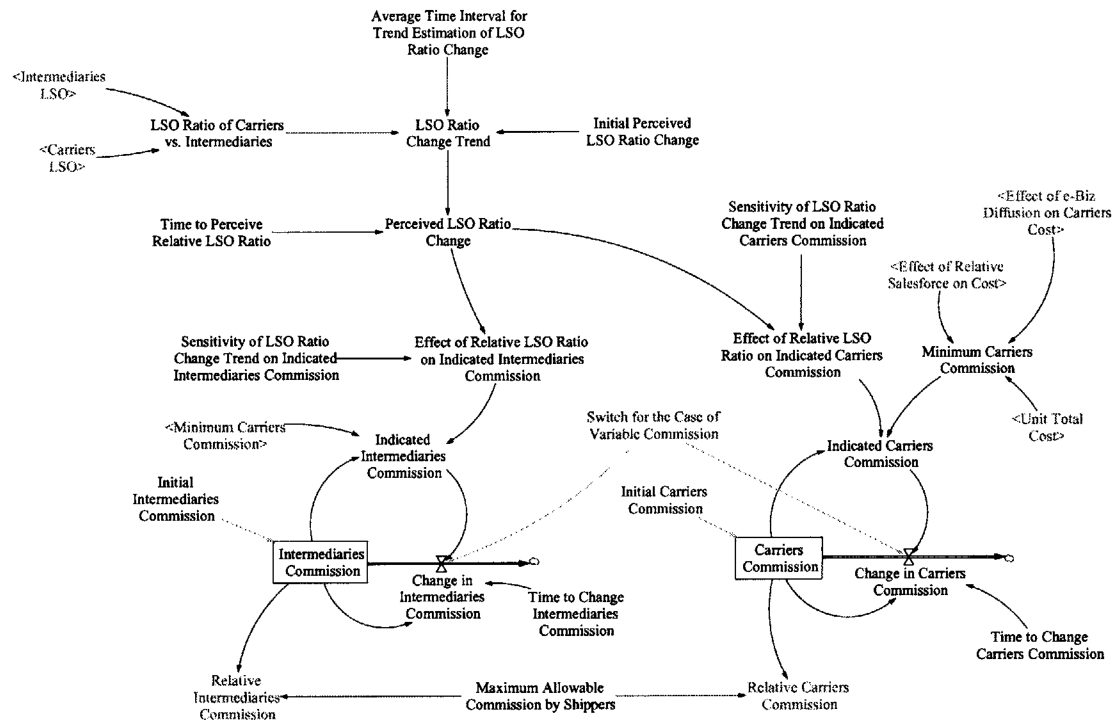


Figure A.3-5 Structure of LSO Commission Sector

The major inputs to this sector are the levels of LSO (carriers / intermediaries LSO), the effect of relative salesforce on cost, which comes from the salesforce sector, and the unit total cost, which is the output from the model for the dynamics of supply-and-demand in the CSI. The exogenous parameters to this sector include the switch for the case of variable commission, average time interval for trend estimation of LSO ratio change, initial perceived LSO ratio change, time to perceive relative LSO ratio, sensitivity of LSO ratio change trend on indicated carriers commission, sensitivity of LSO ratio change trend on indicated intermediaries commission, time to change carriers commission, time to change intermediaries commission, initial carriers commission, initial intermediaries commission, and the maximum allowable commission by shippers. The output from this sector is the relative carriers commission and the relative intermediaries commission, which are used for the inputs to the market share sector. The detailed equations are provided in the following.

(37) Carriers Commission = INTEG (Change in Carriers Commission, Initial Carriers Commission)

(38) Intermediaries Commission = INTEG (Change in Intermediaries Commission, Initial Intermediaries Commission)

(39) Change in Carriers Commission = Switch for the Case of Variable Commission * ((Indicated Carriers Commission - Carriers Commission) / Time to Change Carriers Commission)

(40) Indicated Carriers Commission = MIN (Maximum Allowable Commission by Shippers, MAX (Minimum Carriers Commission, Carriers Commission*Effect of Relative LSO Ratio on Indicated Carriers Commission))

(41) Minimum Carriers Commission = MAX (0, Unit Total Cost * Effect of Relative Salesforce on Cost)

(42) Effect of Relative LSO Ratio on Indicated Carriers Commission = 1+ Perceived LSO Ratio Change * Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission

(43) Perceived Relative LSO Ratio Change = SMOOTH (LSO Ratio Change Trend, Time to Perceive Relative LSO Ratio)

(44) LSO Ratio Change Trend = TREND("LSO Ratio of Carriers vs. Intermediaries", Average Time Interval for Trend Estimation of LSO Ratio Change , Initial Perceived LSO Ratio Change)

(45) LSO Ratio of Carriers vs. Intermediaries = Carriers LSO/Intermediaries LSO

(46) Change in Intermediaries Commission = Switch for the Case of Variable Commission*((Indicated Intermediaries Commission - Intermediaries Commission) / Time to Change Intermediaries Commission)

(47) Indicated Intermediaries Commission = MIN (Maximum Allowable Commission by Shippers, MAX (Minimum Carriers Commission, Intermediaries Commission*Effect of Relative LSO Ratio on Indicated Intermediaries Commission))

(48) Effect of Relative LSO Ratio on Indicated Intermediaries Commission = 1 + Perceived LSO Ratio Change * Sensitivity of LSO Ratio Change Trend on Indicated Intermediaries Commission

(49) Relative Carriers Commission = Carriers Commission / Maximum Allowable Commission by Shippers

(50) Relative Intermediaries Commission = Intermediaries Commission / Maximum Allowable Commission by Shippers

A.3.6 LSO Revenue Sector

The LSO revenue sector calculates the unit revenue increase of carriers from the logistics service offerings. Figure A.3-6 shows the structure of the LSO revenue sector.

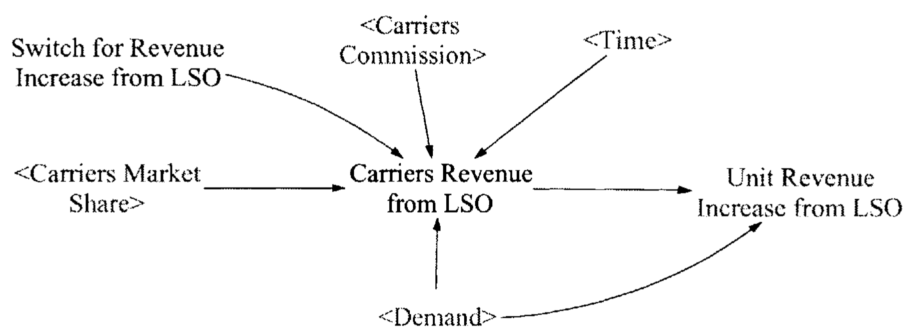


Figure A.3-6 Structure of LSO Revenue Sector

The inputs to this sector are the carriers market share of the logistics service, the carriers commission of the LSO, and the demand, which is the output from the model for the dynamics of supply-and-demand in the CSI. The exogenous parameter of this sector is the switch for revenue increase from LSO, which is used for analyzing the different scenarios. The output from this sector is the unit revenue increase from the LSO, which is used for estimating the profitability of carriers in the model for the dynamics of supply-and-demand in the CSI. The detailed equations are provided in the following.

(51) Carriers Revenue from LSO = IF THEN ELSE (Time < 2001, 0, Switch for Revenue Increase from LSO * (Demand*Carriers Market Share*Carriers Commission))

(52) Unit Revenue Increase from LSO = Carriers Revenue from LSO / Demand

A.3.7 E-Business Diffusion Sector

The e-business diffusion sector models the adoption of e-business by potential e-business users. Just as same as the EDI diffusion sector explained in section 7.4.2, the adoption rate of e-business is simulated using the Bass model, in which two factors determine the adoption rate of e-business: trading partners' demand for e-business as an external source and word-of-mouth effect as an internal source. Figure A.3-7 shows the stock and flow structure for the e-business diffusion sector.

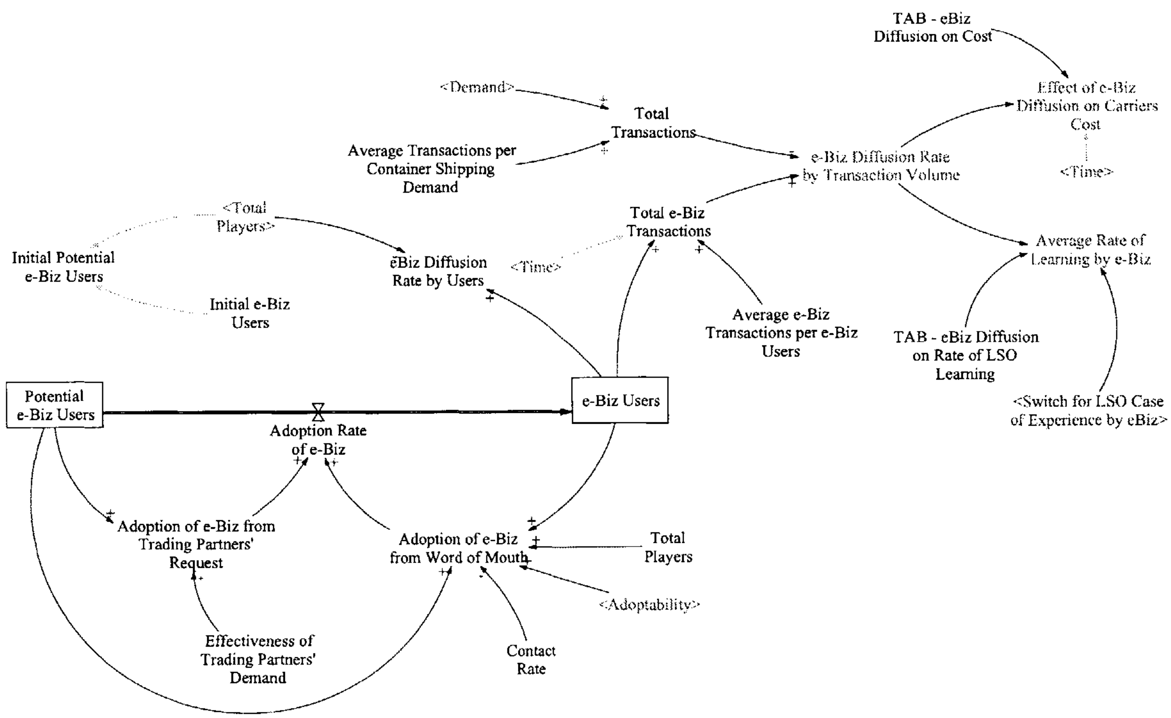


Figure A.3-7 Structure of e-Business Diffusion Sector

The main input to this sector is adoptability, which is calculated from the adoptability sector, and the exogenous parameters to this sector include total players, initial e-business users, contact rate, effectiveness of trading partners' demand, container shipping demand, average transactions per container shipping demand, and average e-business transactions per e-business users. There are three outputs from this sector: "e-biz diffusion rate by transaction volume," which determines the effect of e-business benefits on attractiveness of e-business and the effect of relative competitive advantage on attractiveness of e-business in the adoptability sector; "effect of e-biz diffusion on carriers cost," which controls the change of carriers' operating cost due to the level of e-business adoption rate; and "average rate of learning by e-biz," which determines the average rate of learning LSO in the salesforce sector. The detailed equations are explained in the following.

(53) Potential e-Biz Users = INTEG (- Adoption Rate of e-Biz, Initial Potential e-Biz Users)

(54) e-Biz Users = INTEG (Adoption Rate of e-Biz, Initial e-Biz Users)

(55) Adoption Rate of e-Biz = Adoption of e-Biz from Trading Partners' Demand + Adoption of e-Biz from Word of Mouth

(56) Adoption of e-Biz from Trading Partners' Demand = Potential e-Biz Users * Effectiveness of Trading Partners' Demand

(57) Adoption of e-Biz from Word of Mouth = (Potential e-Biz Users * Contact Rate) * (e-Biz Users / Total Players) * Adoptability

(58) Initial Potential e-Biz Users = Total Players – Initial e-Biz Users

(59) e-Biz Diffusion Rate by Users = e-Biz Users / Total Players

(60) e-Biz Diffusion Rate by Transaction Volume = Total e-Biz Transactions / Total Transactions

(61) Total e-Biz Transactions = Average e-Biz Transactions per e-Biz Users * e-Biz Users

(62) Total Transactions = Average Transactions per Container Shipping Demand * Container Shipping Demand

(63) Effect of e-Biz Diffusion on Carriers Cost = IF THEN ELSE (Time < 2001, 1, "TAB - eBiz Diffusion on Cost"("e-Biz Diffusion Rate by Transaction Volume"))

(64) Average Rate of Learning by e-Biz = Switch for LSO Case of Experience by eBiz * "TAB - eBiz Diffusion on Rate of LSO Learning"("e-Biz Diffusion Rate by Transaction Volume")

A.3.8 Adoptability Sector

The adoptability sector captures how adoptability of e-business is determined from the attractiveness of e-business, which in turn is impacted by the "e-biz diffusion rate by transaction volume." Figure A.3-8 presents the structure of the adoptability sector, which is basically as same as that of the adoptability sector in the EDI diffusion model.

The input to this sector is the "e-biz diffusion rate by transaction volume," which is estimated from the e-business diffusion sector, and the exogenous parameters are normal attractiveness of e-biz and normal adoptability. The output from this sector is the adoptability, which is the input to the e-business diffusion sector. Three nonlinear relationships are described in the table functions of "TAB – eBiz Benefits on Attractiveness," "TAB – Relative Competitive Advantage on Attractiveness," and "TAB – Attractiveness on Adoptability." The detailed equations in the adoptability sector are shown in the following.

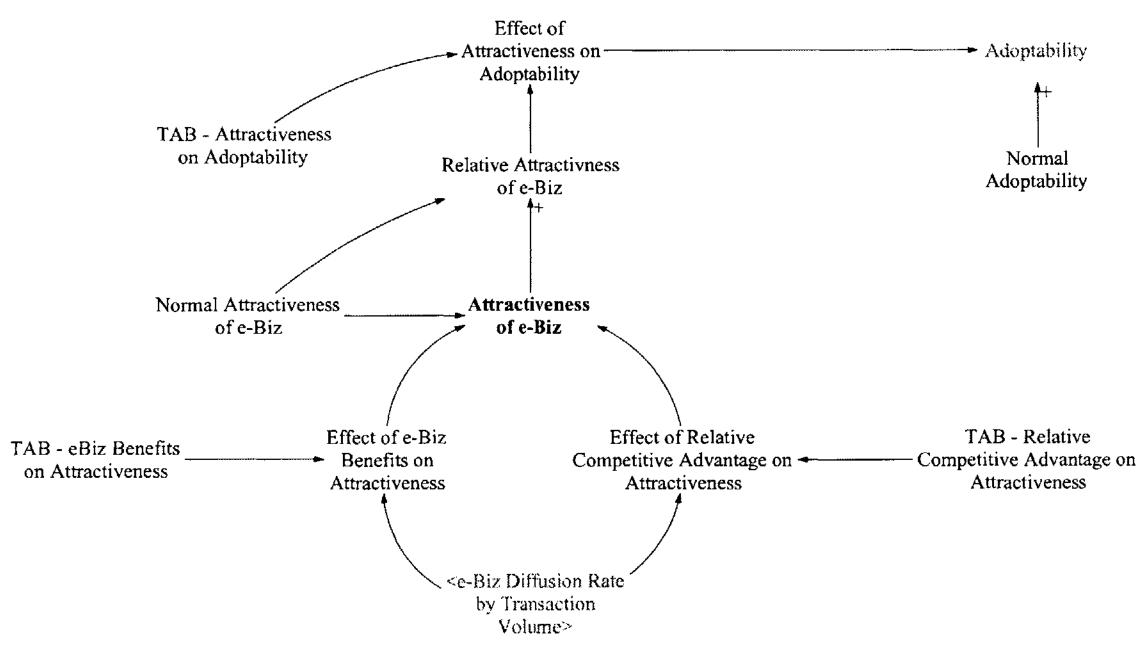


Figure A.3-8 Structure of Adoptability Sector

(65) Adoptability = Normal Adoptability * Effect of Attractiveness of Adoptability

(66) Effect of Attractiveness on Adoptability = "TAB - Attractiveness on Adoptability"(Relative Attractiveness of e-Biz)

(67) Relative Attractiveness of e-Biz = Attractiveness of e-Biz / Normal Attractiveness of e-Biz

(68) Attractiveness of e-Biz = Normal Attractiveness of e-Biz * Effect of e-Biz Benefits on Attractiveness * Effect of Relative Competitive Advantage on Attractiveness

(69) Effect of e-Biz Benefits on Attractiveness = "TAB - eBiz Benefits on Attractiveness" (e-Biz Diffusion Rate by Transaction Volume)

(70) Effect of Relative Competitive Advantage on Attractiveness = "TAB - Relative Competitive Advantage on Attractiveness" (e-Biz Diffusion Rate by Transaction Volume)

A.4 Sensitivity Analysis

In order to test the significance of the different elements in the integrated model, a set of sensitivity analyses is performed for each case – i.e., the future base case, the vertical integration strategy, the virtual integration strategy, and the mixed integration strategy - varying the exogenous parameters. The parameters used for the sensitivity analysis are chosen among the exogenous parameters based on the criteria that (1) the values of parameters were assumed in the simulation due to the lack of available data so that many uncertainties were assumed to be included in the parameters; or (2) the parameters are expected to impact the system's performance substantially from a point of the model structure. To test the sensitivity of the system to each parameter, only one parameter is modified per simulation. Meanwhile, the cumulative unit profit of carriers is used as the main indicator of performance comparison.

A.4.1 Sensitivity Analysis for the Future Base Case

Table A.4-1 presents the percentage change in cumulative unit profit as each of the selected parameters is varied. Six parameters are selected for the sensitivity analysis of the future base case. Each parameter is changed from ±10% to ±25% to ensure the practicality of the parameters. Figure A.4-1 shows the maximum change of cumulative unit profit relative to the variation of each parameter. Two parameters – reference utilization and planning horizon – are identified as most influential to the cumulative unit profit of carriers.

The most sensitive parameters are the reference utilization, which impacts the level of freight rate by comparing the actual utilization level (SensFB-6 in Table A.4-1): The higher the reference utilization, the better the cumulative unit profit. In other words, if carriers increase the reference utilization, the relative utilization, which is the ratio of actual utilization and reference utilization, become lower so that the freight rate tends to decrease. Then, the carriers' revenue and profitability should decline due to the decreased freight rate and carriers should cut back the investment in containership capacity because of declining profitability.

Table A.4-1 Sensitivity Analysis of the Future Base Case - Impact of Parameter Change on the Cumulative Unit Profit

			% Change in Cumulative Unit Profit	
PARAMETER	**Run Name**	**Base Value**	**Lower Value Case**	**Higher Value Case**
Demand Sector				
Globalization Offset Factor	SensFB-1	0.95 Dimensionless	6.4%	-2.7%
Capacity Sector				
Planning Horizon	SensFB-2	14.44 Year	34.7%	-9.0%
Capacity Adjustment Time	SensFB-3	4 Year	-3.1%	3.7%
Target Profitability	SensFB-4	6.42 Dimensionless	-8.0%	12.4%
Effect of Relative Profitability on Order	SensFB-5	TAB – Relative Profitability on Order	2.4%	N/A
Freight Rate Sector				
Reference Utilization	SensFB-6	0.75 Dimensionless	1.7%	18.5%

The second most sensitive parameter is the planning horizon, which is the time frame that carriers consider when ordering the containership capacity (SensFB-2 in Table A.4-1). The shorter the planning horizon, the better the cumulative unit profit in the long term. The reason for this is that, if carriers reduce the planning horizon, they tend to increase the containership capacity only to meet the short-term demand increase with little consideration of the long-term demand increase, so that the containership capacity can increase slowly. Accordingly, the slow increase of containership capacity will increase the utilization of containership capacity; thereby improving the freight rate and the profitability of carriers in the long term.

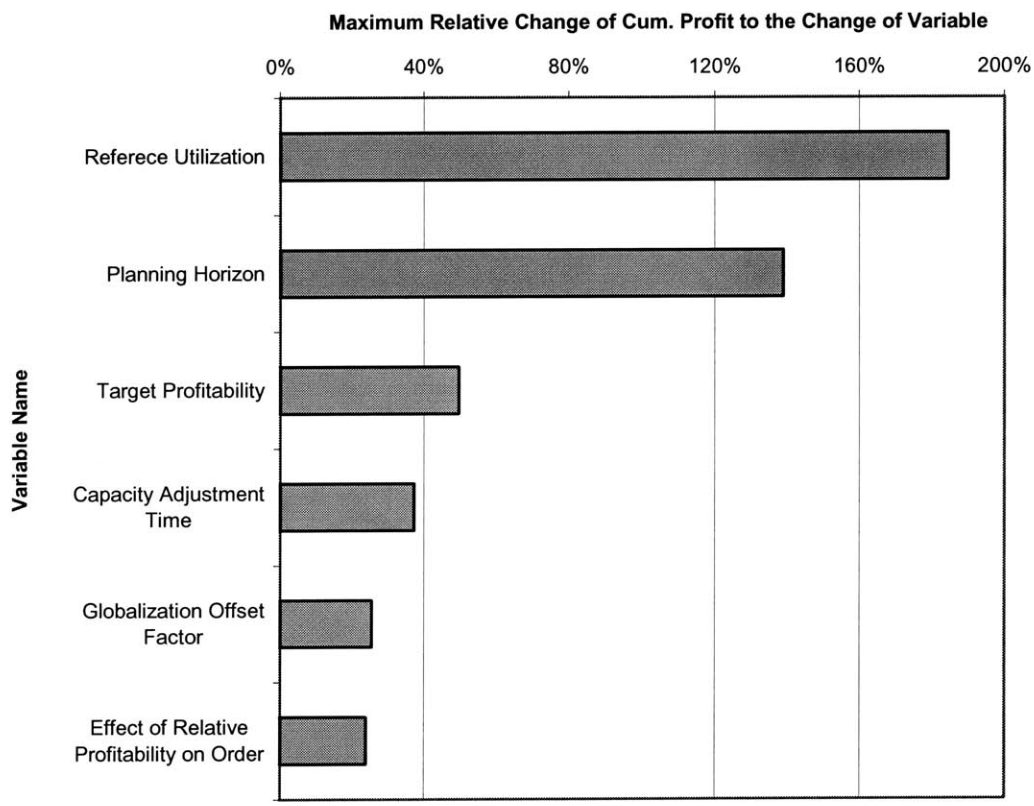


Figure A.4-1 Maximum Relative Sensitivity of the Variables in the Vertical Integration Strategy

A.4.2 Sensitivity Analysis for the Vertical Integration Strategy

Table A.4-2 shows the percentage change in cumulative unit profit as each of the selected parameters is varied ±25%. Fifteen parameters are selected for the sensitivity analysis. Figure A.4-2 presents the maximum percentage change of the cumulative unit profit due to the ±25% variation of each parameter in Table A.4-2.

The most sensitive parameter is the "effect of carriers LSO on attractiveness of carriers service," which controls the impact of relative improvement of the carriers' LSO capability on the attractiveness of carriers logistics service (Sens-12 in Table A.4-2). Lowering the impact of carriers' LSO capability on the attractiveness of carriers' logistics service by 25% decreases the cumulative unit profit by 2.8% while increasing the impact by 25% improves the cumulative unit profit by 2.5%.

The second most sensitive parameter is the "time to change carriers commission," in which if carriers change the LSO commission level more frequently – "time to change carriers commission" is lower than the base value – they can enjoy the better cumulative unit profit from the LSO, and vice versa (Sens-9 in Table A.4-2). If carriers change the level of LSO commission level faster depending on the LSO ratio change than the base case, it will help them generate better profit from the LSO. In addition, this relationship is compatible with the result of sensitivity analysis on the "sensitivity of LSO ratio change trend on indicted carriers commission" (Sens-2 in Table A.4-2). The more sensitive the LSO commission is to the LSO ratio change – the LSO commission changes substantially depending on the LSO ratio change – the more unit profit can carriers make. In summary, quicker change of the LSO commission level might be helpful to carriers.

The "initial development rate of intermediaries LSO" is also expected to impact the overall performance of carriers' profit (Sens-5 in Table A.4-2); the lower the development rate of intermediaries LSO, the better the cumulative unit profit is. In other words, the potential profitability of carriers from the LSO is dependent upon the relative improvement of intermediaries' LSO capability.

The next sensitive parameter is the "hiring increase rate for LSO," which is the carriers' policy to develop the number of salesforce for improving the LSO capability (Sens-7 in Table A.4-2). Interestingly, this sensitivity is counter-intuitive: the higher the hiring increase rate for LSO, the lower the cumulative unit profit is – i.e., if carriers try to hire more salespeople serving for the logistics service, carriers could be less profitable. The reason for this is as follows: When carriers hire more salespeople, total carriers' revenue might increase due to the improved carriers' LSO capability. However, hiring more salespeople could make carriers increase the total costs associated with offering the logistics service. In fact, the cost increase from hiring more salespeople is higher than the revenue increase from the improved LSO capability, so that carriers could be less profitable by hiring more salespeople. In other words, the higher the hiring increase rate for LSO, the lower the cumulative profit of carriers, because the costs associated with the additional salespeople outnumber the unit revenue increase from the LSO. This analysis shows that the cost impact of hiring additional salespeople is important in developing the LSO through the vertical integration strategy. This reasoning can be confirmed by investigating the sensitivity of the model to the cost factor, which is explained in the following.

The LSO model is also expected to be sensitive to the parameter of "cost sensitivity to relative salesforce," which determines the cost associated with developing the logistics service of carriers (Sens-1 in Table A.4-2). Lowering the cost sensitivity by 25% increases the cumulative unit profit by 1.2% whereas increasing the cost sensitivity by 25% rather decreases the cumulative unit profit by 1.2%. Lowering the costs associated with recruiting additional salesforce can therefore improve the profitability of carriers directly. This analysis shows that it is necessary to carefully manage the costs of hiring more salesforce developing the LSO capability while not compromising the quality of salesforce.

Finally, the change of the "effect of intermediaries commission on attractiveness of intermediaries service" (Sens-15 in Table A.4-2) impacts the system's performance. The lower the "effect of intermediaries commission on attractiveness of intermediaries service," the better off is the carriers' profitability.

Meanwhile, two parameters are expected to hardly impact the profitability of carriers in the LSO dynamics. First, the change of "average rate of learning by salesforece," which represents that more salesforce will be likely to expedite the rate of learning of the logistics service among salespeople, provides negligible impact on carriers' cumulative unit profit (Sens-11 in Table A.4-2). In other words, for example, even though carriers introduce the policy of expediting the sharing of the experience of selling logistics service among the salesforce, it might not improve the carriers' overall profitability from the LSO as desired. The second parameter is the "shippers' carriers LSO perception time," which models how fast shippers recognize the improvement of the carriers' LSO capability (Sens-8 in Table A.4-2). Even if shippers realize the change of carriers' LSO capability faster, the improvement of carriers' profitability is expected to be minimal. That is, the carriers' marketing efforts of advertising the improvement of their LSO capability might not be effective enough to generate better profitability.

Table A.4-2 Sensitivity Analysis of the Vertical Integration Strategy - Impact of Parameter Change on the Cumulative Unit Profit

PARAMETER	Run Name	Base Value		% Change in Cumulative Unit Profit: 0.75 * Base Value	% Change in Cumulative Unit Profit: 1.25 * Base Value
Exogenous Input Variables					
Cost Sensitivity to Relative Salesforce	Sens-1	0.08	Dimensionless	1.2%	-1.2%
Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission	Sens-2	0.28	Fraction * Year	-1.3%	1.3%
Sensitivity of LSO Ratio Change Trend on Indicated Intermediaries Commission	Sens-3	-0.28	Fraction * Year	0.3%	-0.5%
Maximum Allowable Commission by Shippers	Sens-4	200	$ / TEU	-0.4%	0.1%
Reference Points for Decision-making					
Initial Development Rate of Intermediaries LSO	Sens-5	0.07	Fraction / Year	1.3%	-1.3%
Annual Decay Rate of Development Rate	Sens-6	0.03	Fraction / Year	-0.3%	0.2%
Hiring Increase Rate for LSO	Sens-7	0.5	Dimensionless	1.3%	-1.3%
Information Delay Time					
Shippers' Carriers LSO Perception Time	Sens-8	0.5	Years	0.1%	-0.1%
Time to Change Carriers Commission	Sens-9	1	Years	**1.7%**	**-1.0%**
Nonlinear Relationships					
Effect of Relative Profitability on Hiring	Sens-10	TAB – Relative Profitability on Hiring		-0.5%	0.4%
Average Rate of Learning by Salesforce	Sens-11	TAB – Relative Salesforce on Rate of Learning		-0.1%	0.1%
Effect of Carriers LSO on Attractiveness of Carriers Service	Sens-12	TAB - Carriers LSO on Attractiveness of Carriers Service		**-2.8%**	**2.5%**
Effect of Intermediaries LSO on Attractiveness of Intermediaries Service	Sens-13	TAB - Intermediaries LSO on Attractiveness of Intermediaries Service		0.7%	-0.6%
Effect of Carriers Commission on Attractiveness of Carriers Service	Sens-14	TAB - Relative LSO Ratio on Indicated Carriers Commission		-0.7%	0.5%
Effect of Intermediaries Commission on Attractiveness of Intermediaries Service	Sens-15	TAB - Relative LSO Ratio on Indicated Intermediaries Commission		1.1%	-1.0%

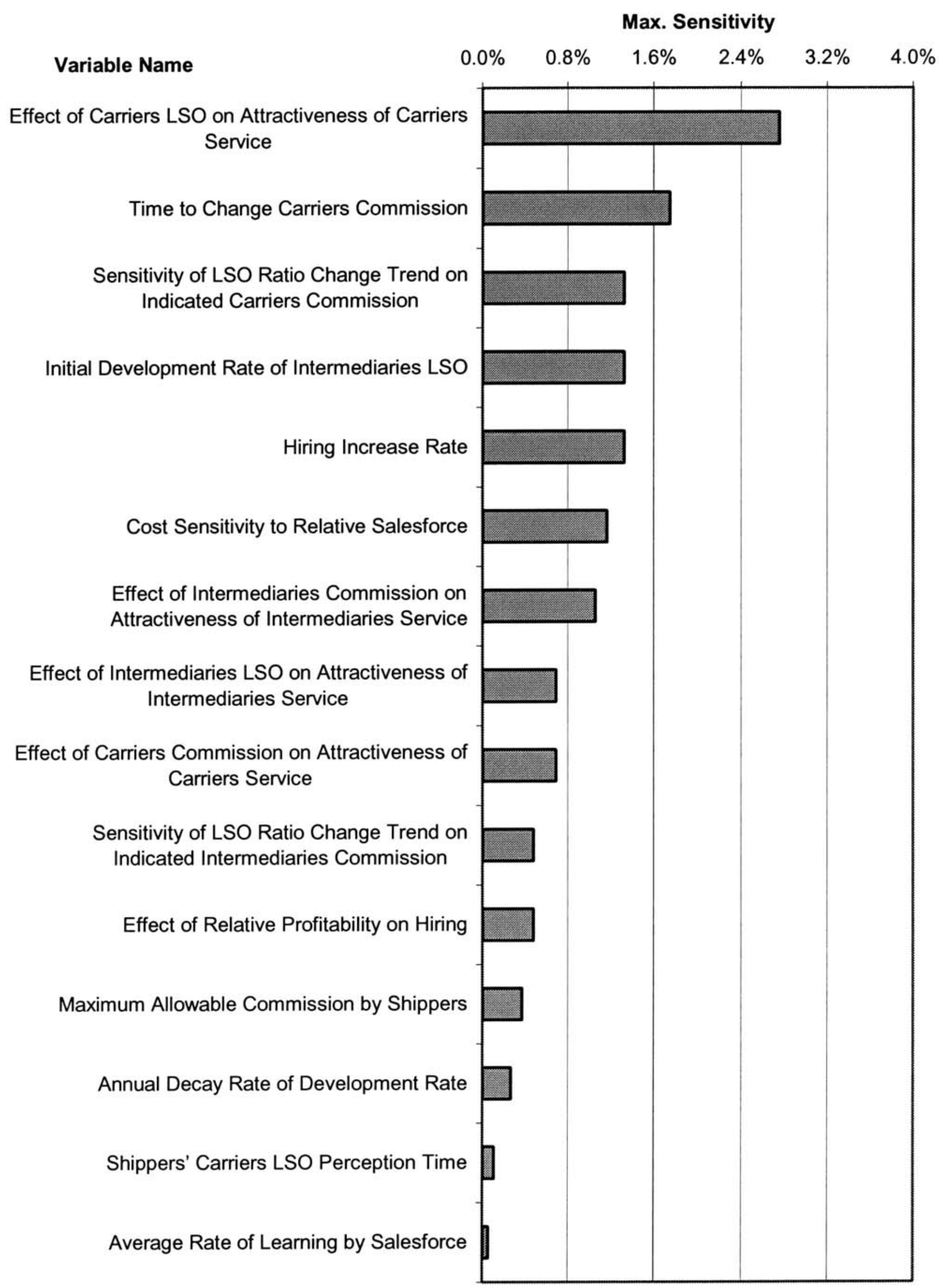


Figure A.4-2 Maximum Sensitivity of the Variables in the Vertical Integration Strategy

A.4.3 Sensitivity Analysis for the Virtual Integration Strategy

Table A.4-3 shows the percentage change in cumulative unit profit as each of the selected parameters is varied ±25%. Eighteen parameters are selected for the sensitivity analysis. The parameters that are related to increasing the number of salesforce are excluded for testing the sensitivity of the e-business model, and the parameters, which are related to the e-business diffusion dynamics, are added for the sensitivity analysis of the e-business model. To test the sensitivity of the system to each parameter, only one parameter is modified per simulation. The tests can be used to detect the policies with greater leverage. Figure A.4-3 presents the maximum percentage change of the cumulative unit profit due to the ±25% variation of each parameter in Table A.4-3. In addition, the percentage changes of e-business diffusion rate corresponding to the change of e-business related parameters are also shown in Table A.4-4 to understand how much the diffusion rate of e-business is impacted by the variation of parameters.

The most sensitive parameter in case of virtual integration strategy is the "effect of relative competitive advantage on attractiveness," which makes the adoption of e-business slower as the diffusion rate of e-business increases (SensVi-17 in Table A.4-3). Lowering the effect of relative competitive advantage by 25% increases the cumulative unit profit by 7.6% and also the e-business diffusion rate by 21%. Meanwhile, increasing the effect of relative competitive advantage by 25% rather decreases the cumulative unit profit by 5.8% and the e-business diffusion rate by 14.8%. This sensitivity of the model to the effect of relative competitive advantage can be explained by the fact that the lowered effect of relative competitive advantage reduces the impact of balancing "competitive advantage" feedback loop (see section 7.3.3) so that the diffusion rate of e-business could rather increase, and vice versa. In other words, if the competitive advantage of adopting the e-business maintains even in higher level of e-business diffusion rate, the adoption rate of e-business could increase substantially, which therefore makes carriers more profitable in the end. On the other hand, if the competitive advantage of joining the e-business activities erodes quickly when the diffusion rate of e-business becomes high, the adoption rate of e-business could decrease fast so that carriers' profitability becomes lower in the long term.

The second most sensitive parameter is the "effect of e-business diffusion on cost," which determines the cost associated with developing the logistics service by adopting e-business activities (SensVi-9 in Table A.4-3). Lowering the cost impact by 25% decreases the cumulative unit profit by 2.8% whereas increasing the cost impact by 25% rather increases the cumulative unit profit by 7.1%. In other words, if the long-term cost savings from adopting e-business become more substantial than the base case, i.e., increasing the cost impact, then the cumulative unit profit of carriers is expected to be better than the base case, and vice versa. This analysis shows that the benefit of cost savings from adopting e-business for the logistics service is crucial to determining the long-term profitability of carriers.

The next sensitive parameter is the "effect of carriers LSO on attractiveness of carriers service," which controls the impact of relative improvement of carriers LSO capability on the attractiveness of carriers logistics service (SensVi-10 in Table A.4-3). Lowering the impact of carriers' LSO capability on the attractiveness of carriers' logistics service by 25% decreases the cumulative unit profit by 4.9% while increasing the impact by 25% improves the cumulative unit profit by 5.2%.

Table A.4-3 Sensitivity Analysis of the Virtual Integration Strategy- Impact of Parameter Change on the Cumulative Unit Profit

PARAMETER	Run Name	Base Value		% Change in Cumulative Unit Profit: 0.75 * Base Value	% Change in Cumulative Unit Profit: 1.25 * Base Value
Exogenous Input Variables					
Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission	SensVi-1	0.28	Fraction * Year	-1.6%	1.9%
Sensitivity of LSO Ratio Change Trend on Indicated Intermediaries Commission	SensVi-2	-0.28	Fraction * Year	0.4%	-0.4%
Maximum Allowable Commission by Shippers	SensVi-3	200	$ / TEU	-0.2%	0.3%
Reference Points for Decision-making					
Initial Development Rate of Intermediaries LSO	SensVi-4	0.07	Fraction / Year	2.6%	-2.5%
Annual Decay Rate of Development Rate	SensVi-5	0.03	Fraction / Year	-0.5%	0.4%
Information Delay Time					
Shippers' Carriers LSO Perception Time	SensVi-6	0.5	Years	0.2%	-0.2%
Time to Change Carriers Commission	SensVi-7	1	Years	3.3%	-1.6%
Nonlinear Relationships					
Average rate of Learning by e-Biz	SensVi-8	TAB - eBiz Diffusion on Rate of LSO Learning		-0.3%	0.3%
Effect of e-Biz Diffusion on Carriers Cost	SensVi-9	TAB - eBiz Diffusion on Cost		**-2.8%**	**7.1%**
Effect of Carriers LSO on Attractiveness of Carriers Service	SensVi-10	TAB - Carriers LSO on Attractiveness of Carriers Service		-4.9%	5.2%
Effect of Intermediaries LSO on Attractiveness of Intermediaries Service	SensVi-11	TAB - Intermediaries LSO on Attractiveness of Intermediaries Service		1.5%	-1.4%
Effect of Carriers Commission on Attractiveness of Carriers Service	SensVi-12	TAB - Relative LSO Ratio on Indicated Carriers Commission		-0.7%	0.4%
Effect of Intermediaries Commission on Attractiveness of Intermediaries Service	SensVi-13	TAB - Relative LSO Ratio on Indicated Intermediaries Commission		1.2%	-1.3%
e-Biz Diffusion Related Variables					
Effect of Trading Partners' Demand	SensVi-14	0.02	Fraction / Year	-0.5%	0.1%

PARAMETER	Run Name	Base Value	% Change in Cumulative Unit Profit	
			0.75 * Base Value	**1.25 * Base Value**
Contact Rate	SensVi-15	11 Fraction / Year	-0.5%	1.2%
Effect of e-Biz Benefits on Attractiveness	SensVi-16	TAB - eBiz Benefits on Attractiveness	-4.9%	4.7%
Effect of Relative Competitive Advantage on Attractiveness	SensVi-17	TAB - Relative Competitive Advantage on Attractiveness	**7.6%**	**-5.8%**
Effect of Attractiveness on Adoptability	SensVi-18	TAB - Attractiveness on Adoptability	0.8%	-0.2%

Table A.4-4 Sensitivity Analysis of the Virtual Integration Strategy - Impact of Parameter Change on the e-Business Diffusion Rate

e-Biz Diffusion Related Variables	Run Name	% Change in e-Biz Diffusion by Users in 2020		% Change in e-Biz Diffusion by Transaction Volume in 2020	
		0.75 * Base Value	**1.25 * Base Value**	**0.75 * Base Value**	**1.25 * Base Value**
Effect of Trading Partners' Demand	SensVi-14	-0.3%	0.3%	-0.3%	0.3%
Contact Rate	SensVi-15	-2.4%	1.7%	-2.4%	1.7%
Effect of e-Biz Benefits on Attractiveness	SensVi-16	-14.5%	13.5%	-14.5%	13.5%
Effect of Relative Competitive Advantage on Attractiveness	SensVi-17	21.1%	-14.8%	21.1%	-14.8%
Effect of Attractiveness on Adoptability	SensVi-18	-0.1%	0.3%	-0.1%	0.3%

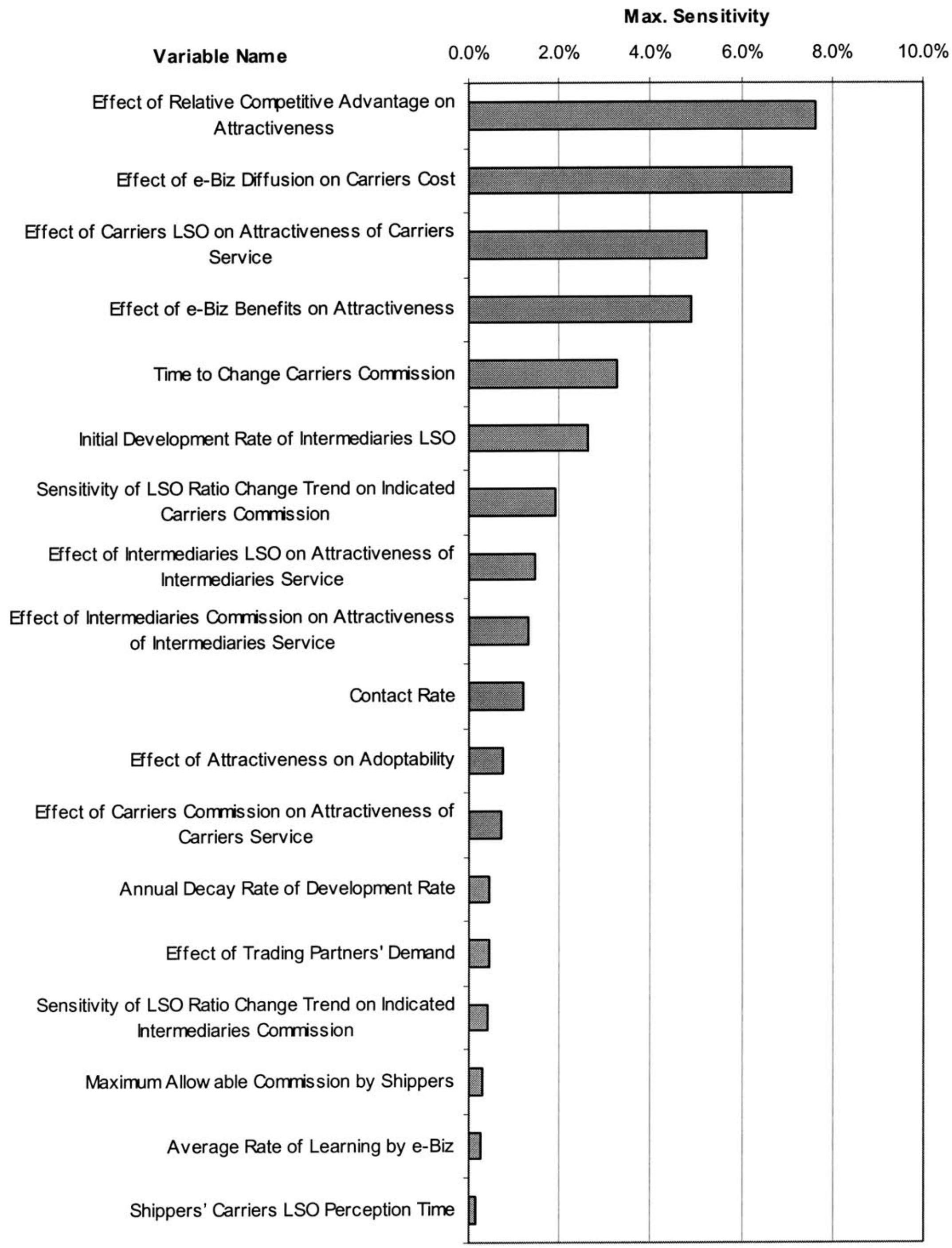


Figure A.4-3 Maximum Sensitivity of the Variables in the Virtual Integration Strategy

The "effect of e-business benefits on attractiveness," which explains the increasing adoption rate of e-business as the benefits of e-business increases (see section 7.3.2 and 7.4.3), is also expected to impact the overall performance of carriers' profit (SensVi-16 in Table A.4-3); the higher the effect of e-business benefits on attractiveness of e-business, the higher the diffusion rate of e-business and the carriers' profitability in the end. Compared with the base case, lowering the effect by 25% decreases the diffusion rate of e-business in 2020 by 14.5% and the cumulative unit profit by 4.9%, whereas increasing the effect by 25% rather increases the diffusion rate of e-business in 2020 by 13.5% and the cumulative unit profit by 4.7%.

In addition, the next sensitive parameter is the "time to change carriers commission," in which if carriers change the LSO commission level more frequently – "time to change carriers commission" is lower than the base value – they can enjoy the better cumulative profit from the LSO, and vice versa (SensVi-7 in Table A.4-3). If carriers change the level of LSO commission level faster depending on the LSO ratio change than the base case, it will help them generate better profit from the LSO. Furthermore, this relationship is compatible with the result of sensitivity analysis on the "sensitivity of LSO ratio change trend on indicted carriers commission" (SensVi-1 in Table A.4-3). The more sensitive the LSO commission is to the LSO ratio change – the LSO commission changes substantially depending on the LSO ratio change – the more unit profit can carriers make. In summary, quicker change of the LSO commission level might be helpful to carriers.

Finally, the "initial development rate of intermediaries LSO" is also expected to impact the overall performance of carriers' profit (SensVi-4 in Table A.4-3); the lower the development rate of intermediaries LSO, the better the cumulative unit profit is. In other words, the potential profitability of carriers from the LSO is dependent upon the relative improvement of intermediaries' LSO capability.

Meanwhile, two parameters are expected to hardly impact the profitability of carriers in the LSO dynamics. First, the change of "average rate of learning by e-Biz," which represents that higher diffusion rate of e-business will be likely to expedite the rate of learning of the logistics service among salespeople, provides negligible impact on carriers' cumulative unit profit (SensVi-8 in Table A.4-3). In other words, the benefit of increasing the LSO capability by adopting e-business activities is less effective in generating the profit of carriers from the logistics service. The second parameter is the "shippers' carriers LSO perception time," which models how fast shippers recognize the improvement of the carriers' LSO capability (SensVi-6 in Table A.4-3). Even if shippers realize the change of carriers' LSO capability faster, the improvement of carriers' profitability is expected to be minimal. That is, the carriers' marketing efforts of advertising the improvement of their LSO capability might not be effective enough to generate better profitability.

A.4.4 Sensitivity Analysis for the Mixed Integration Strategy

In order to test the significance of the different elements in the integrated model, a set of simulations is performed varying the exogenous parameters. The simulations are compared using the cumulative unit profit of carriers as the main indicator of performance. The simulation result of the MX-1 scenario is used as the base simulation

Table A.4-5 shows the percentage change in cumulative unit profit as each of the selected parameters is varied ±25%. Combining the parameters that were used for the sensitivity analyses for the vertical and virtual integration strategies, twenty-two parameters are selected for the sensitivity analysis of the integrated model. To test the sensitivity of the system to each parameter, only one parameter is modified per simulation. Figure A.4-4 presents the maximum percentage change of the cumulative unit profit due to the ±25% variation of each parameter in Table A.4-5. In addition, the percentage changes of e-business diffusion rate corresponding to the change of e-business related parameters are also shown in Table A.4-6 to understand how much the diffusion rate of e-business is impacted by the variation of parameters.

The sensitivity analysis shows that two e-business related parameters are the most influential to the system's performance. The most sensitive parameter in case of mixed integration strategy is the "effect of relative competitive advantage on attractiveness," which makes the adoption of e-business slower as the diffusion rate of e-business increases (SensMX-21 in Table A.4-5). Lowering the effect of relative competitive advantage by 25% increases the cumulative unit profit by 4% and also the e-business diffusion rate by 21%. Meanwhile, increasing the effect of relative competitive advantage by 25% rather decreases the cumulative unit profit by 3.6% and the e-business diffusion rate by 14.8%. In addition, the "effect of e-business benefits on attractiveness," which explains the increasing adoption rate of e-business as the benefits of e-business increases (see section 7.3.2 and 7.4.3), is expected to be the second most sensitive parameter (SensMX-20 in Table A.4-5); the higher the effect of e-business benefits on attractiveness of e-business, the higher the diffusion rate of e-business and the carriers' profitability in the end. Compared with the base case, lowering the effect by 25% decreases the cumulative unit profit by 3.1% and the diffusion rate of e-business in 2020 by 14.5%, whereas increasing the effect by 25% rather increases the cumulative unit profit by 2.7% and the diffusion rate of e-business in 2020 by 13.5%.

Next, the "effect of e-business diffusion on cost," which determines the cost associated with developing the logistics service by adopting e-business activities, also impacts the overall performance of the cumulative unit profit (SensMX-13 in Table A.4-5). In particular, increasing the cost impact of e-business changes the cumulative unit profit substantially than the case of decreasing the cost impact: Increasing the cost impact by 25% increases the cumulative unit profit by 3% whereas lowering the cost impact by 25% decreases the cumulative unit profit by 0.6% only. Besides the cost impact from the virtual integration strategy, the integrated model is also expected to be sensitive to the cost parameter of the vertical integration strategy – "cost sensitivity to relative salesforce," which determines the cost associated with developing the logistics service of carriers through the vertical integration strategy (SensMX-1 in Table A.4-5). Lowering the cost sensitivity by 25% increases the cumulative unit profit by 1.1% whereas increasing the cost sensitivity by 25% rather decreases the cumulative unit profit by 0.9%. Lowering the costs of recruiting additional salesforce can therefore improve the profitability of carriers directly. This analysis shows that it is necessary to carefully manage the costs of hiring more salesforce developing the LSO capability while not compromising the quality of salesforce. This conclusion is also confirmed by the sensitivity analysis for the "hiring increase rate for LSO," which is explained below.

The next sensitive parameter is the "effect of carriers LSO on attractiveness of carriers service," which controls the impact of relative improvement of carriers' LSO capability on the attractiveness of carriers logistics service (SensMX-14 in Table A.4-5). Lowering the impact of carriers' LSO capability on the attractiveness of carriers' logistics service by 25% decreases the cumulative unit profit by 2.8% while increasing the impact by 25% improves the cumulative unit profit by 2.7%.

In addition, the next sensitive parameter is the "time to change carriers commission," in which if carriers change the LSO commission level more frequently – "time to change carriers commission" is lower than the base value – they can enjoy the better cumulative profit from the LSO, and vice versa (SensMX-9 in Table A.4-5). If carriers change the level of LSO commission level faster depending on the LSO ratio change than the base case, it will help them generate better profit from the LSO. Moreover, this relationship is compatible with the result of sensitivity analysis on the "sensitivity of LSO ratio change trend on indicted carriers commission" (SensMX-2 in Table A.4-5). The more sensitive the LSO commission is to the LSO ratio change – the LSO commission changes substantially depending on the LSO ratio change – the more unit profit can carriers make. In summary, as in the VE-4 and Vi-4 scenarios, quicker change of the LSO commission level might be helpful to carriers in the mixed integration strategy.

The "initial development rate of intermediaries LSO," which models how fast intermediaries would improve their LSO capability, is also expected to impact the overall performance of carriers' profit (SensMX-5 in Table A.4-5); the lower the development rate of intermediaries LSO, the better cumulative unit profit does carriers achieve. In other words, the potential profitability of carriers from the LSO is dependent upon the relative improvement of intermediaries' LSO capability.

Furthermore, the next sensitive parameter is the "hiring increase rate for LSO," which is the carriers' policy to develop the number of salesforce for improving the LSO capability (SensMX-7 in Table A.4-5). Similar to the vertical integration strategy (see Table A.4-5), this sensitivity is counter-intuitive: the higher the hiring increase rate for LSO, the lower the cumulative unit profit is – i.e., if carriers try to hire more salespeople serving for the logistics service, carriers could be less profitable. The reason for this is as follows: When carriers hire more salespeople, total carriers' revenue might increase due to the improved carriers' LSO capability. However, hiring more salespeople could make carriers increase the total costs associated with offering the logistics service. In fact, the cost increase from hiring more salespeople is higher than the revenue increase from the improved LSO capability, so that carriers could be less profitable by hiring more salespeople. In other words, the higher the hiring increase rate for LSO, the lower the cumulative profit of carriers, because the costs associated with the additional salespeople outnumber the unit revenue increase from the LSO. This analysis shows that the cost impact of hiring additional salespeople is important in developing the LSO through the mixed integration strategy.

Finally, two parameters affecting the adoption rate of e-business are expected to impact the performance of cumulative unit profit: the "contact rate" and the "effect of trading partners' demand." (SensMX-18 and SensMX-19 in Table A.4-5). Increasing these parameters improves the cumulative unit profit whereas decreasing them rather lowers the profitability. However, it is worth mentioning that, even though increasing those parameters does not change substantially the cumulative unit profit, the impact of decreasing them is relatively more substantial. Therefore, carriers' profitability might be worse unless the container shipping industry maintains the current levels of the "contact rate" and the "effect of trading partners' demand."

Table A.4-5 Sensitivity Analysis of the Mixed Integration Strategy - Impact of Parameter Change on the Cumulative Unit Profit

PARAMETER	Run Name	Base Value		% Change in Cumulative Unit Profit: 0.75 * Base Value	% Change in Cumulative Unit Profit: 1.25 * Base Value
Exogenous Input Variables					
Cost Sensitivity to Relative Salesforce	SensMX-1	0.08	Dimensionless	1.1%	-0.9%
Sensitivity of LSO Ratio Change Trend on Indicated Carriers Commission	SensMX-2	0.28	Fraction * Year	-0.6%	1.0%
Sensitivity of LSO Ratio Change Trend on Indicated Intermediaries Commission	SensMX-3	-0.28	Fraction * Year	0.3%	-0.2%
Maximum Allowable Commission by Shippers	SensMX-4	200	$ / TEU	-0.1%	0.2%
Reference Points for Decision-making					
Initial Development Rate of Intermediaries LSO	SensMX-5	0.07	Fraction / Year	1.4%	-1.3%
Annual Decay Rate of Development Rate	SensMX-6	0.03	Fraction / Year	-0.2%	0.3%
Hiring Increase Rate	SensMX-7	0.5	Dimensionless	1.3%	-1.1%
Information Delay Time					
Shippers' Carriers LSO Perception Time	SensMX-8	0.5	Years	0.2%	-0.1%
Time to Change Carriers Commission	SensMX-9	1	Years	1.8%	-0.8%
Nonlinear Relationships					
Effect of Relative Profitability on Hiring	SensMX-10	TAB – Relative Profitability on Hiring		-0.7%	0.4%
Average Rate of Learning by Salesforce	SensMX-11	TAB – Relative Salesforce on Rate of Learning		0.1%	0.1%
Average rate of Learning by e-Biz	SensMX-12	TAB - eBiz Diffusion on Rate of LSO Learning		-0.1%	0.2%
Effect of e-Biz Diffusion on Carriers Cost	SensMX-13	TAB - eBiz Diffusion on Cost		-0.6%	3.0%
Effect of Carriers LSO on Attractiveness of Carriers Service	SensMX-14	TAB - Carriers LSO on Attractiveness of Carriers Service		-2.8%	2.7%
Effect of Intermediaries LSO on Attractiveness of Intermediaries Service	SensMX-15	TAB - Intermediaries LSO on Attractiveness of Intermediaries Service		0.8%	-0.7%

PARAMETER	Run Name	Base Value	% Change in Cumulative Unit Profit	
			0.75 * Base Value	1.25 * Base Value
Effect of Carriers Commission on Attractiveness of Carriers Service	SensMX-16	TAB - Relative LSO Ratio on Indicated Carriers Commission	-0.3%	-0.1%
Effect of Intermediaries Commission on Attractiveness of Intermediaries Service	SensMX-17	TAB - Relative LSO Ratio on Indicated Intermediaries Commission	0.3%	-0.6%
e-Biz Diffusion Related Variables				
Effect of Trading Partners' Demand	SensMX-18	0.02 Fraction / Year	-1.0%	0.3%
Contact Rate	SensMX-19	11 Fraction / Year	-1.3%	0.6%
Effect of e-Biz Benefits on Attractiveness	SensMX-20	TAB - eBiz Benefits on Attractiveness	-3.1%	2.7%
Effect of Relative Competitive Advantage on Attractiveness	SensMX-21	TAB - Relative Competitive Advantage on Attractiveness	4.0%	-3.6%
Effect of Attractiveness on Adoptability	SensMX-22	TAB - Attractiveness on Adoptability	-0.1%	0.2%

Table A.4-6 Sensitivity Analysis of the Mixed Integration Strategy - Impact of Parameter Change on the e-Business Diffusion Rate

e-Biz Diffusion Related Variables	Run Name	% Change in e-Biz Diffusion by Users in 2020		% Change in e-Biz Diffusion by Transaction Volume in 2020	
		0.75 * Base Value	1.25 * Base Value	0.75 * Base Value	1.25 * Base Value
Effect of Trading Partners' Demand	SensMX-18	-0.3%	0.3%	-0.3%	0.3%
Contact Rate	SensMX-19	-2.4%	1.7%	-2.4%	1.7%
Effect of e-Biz Benefits on Attractiveness	SensMX-20	-14.5%	13.5%	-14.5%	13.5%
Effect of Relative Competitive Advantage on Attractiveness	SensMX-21	21.1%	-14.8%	21.1%	-14.8%
Effect of Attractiveness on Adoptability	SensMX-22	-0.1%	0.3%	-0.1%	0.3%

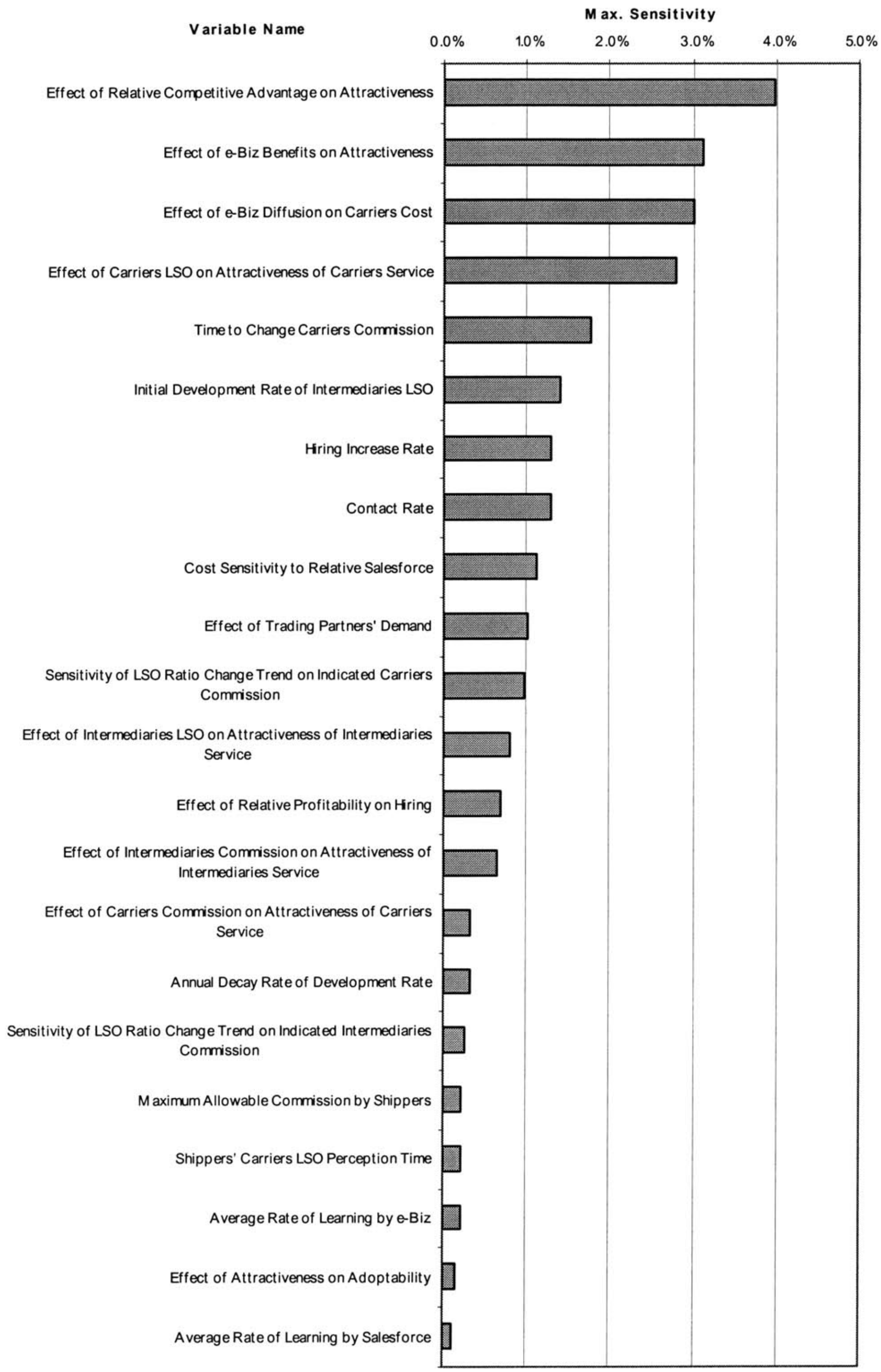


Figure A.4-4 Maximum Sensitivity of the Variables in the Mixed Integration Strategy

Abbreviation

3PL	3rd Party Logistics Company
A-CA	Appropriability – Complimentary Assets
CSI	Container Shipping Industry
CTP	Collaborative Tool Provider
e-business	Internet-based Business
e-CSP	e-Chartering Service Provider
EDI	Electronic Data Interchange
e-PSP	e-Procurement Service Provider
LSO	Logistics Service Offering
MT-CF	Market Type – Customer Focus
NE-CL	Network Externality – Customer Lock-in
OSRA	Ocean Shipping Reform Act

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