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The impacts of online direct channel on pricing strategy and profits: a conceptual application to container shipping company

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THE IMPACTS OF ONLINE DIRECT CHANNEL ON PRICING STRATEGY AND PROFITS
- A CONCEPTUAL APPLICATION TO CONTAINER SHIPPING COMPANY

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): **..**

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Abstract

Title of Dissertation: **The impacts of online direct channel on pricing strategy and profits - A conceptual application to container shipping company**

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E-commerce has been an emerging concept and is widely applied within several different industry sectors. The most crucial and growing questions for container shipping companies are whether to engage in shipping e-commerce and how to set the online direct price if so. In order to propose a valuable and applicable pricing strategy for a container shipping company in e-commerce environment, the dissertation originally applies the pricing strategy in the dual-channel supply chain in the container shipping industry.

Firstly, a modified conceptual dual-channel supply chain in the container shipping industry is constructed. Secondly, seven factors which influence pricing strategy and profits are selected and discussed as inputs to profit models. Thirdly, Nash equilibrium game theory and consumer utility theory are applied synthetically to construct models. After constructing and optimizing profit models, the optimal pricing strategy for container shipping company is proposed to supplement the relevant decision-making framework. Fourthly, the effects of independent variables on the pricing strategy and profits are discussed in-depth through numerical examples with reference to real market data provided by an international shipping company. The results indicate that the online selling channel has not yet been developed for a container shipping company to enter into e-commerce because of the high initial investment and low cargo owners' preference for online direct channel. Moreover, the results show that the optimal pricing strategy is dynamic with changes in inputs. If container shipping companies set the online direct price randomly, they may lose customers and profit.

The dissertation not only opens up a research field on pricing strategy in the dual-channel supply chain in the container shipping industry, but also establishes an applicable pricing strategy for a container shipping company.

KEYWORDS: dual-channel supply chain, pricing strategy, Nash equilibrium, consumer utility theory, container shipping industry.

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LIST OF ABBREVIATIONS

CSI	Container Shipping Industry
DST	Double-stack train
EDI	Electronic Data Interchange
NVOCC	Non-Vessel Operating Common Carrier
OECD	Organization for Economic Co-operation and Development
WTO	World Trade Organization

Chapter 1 : INTRODUCTION

This chapter explains the nature of the container shipping industry and the emergence of e-commerce in the industry. Thus, an overview of the importance of a pricing strategy for the container shipping industry in the context of e-commerce environment is emphasized.

1.1. Background

The characteristics of container shipping industry and the emergence of e-commerce in container shipping industry are described as follows.

1.1.1. Container shipping industry

The container shipping industry (CSI) is an intricate market which has distinct freight rate mechanisms rather than any economic explanations of demand and supply. Under the law of supply and demand, equilibrium price is difficult to identify due to the influences of different variables. Profitability is critical to the sustainability of shipping firms.

Container shipping companies are vulnerable to crisis. Since the invention of containers in 1956, the CSI has been confronted with several crises. The crises are the two oil crises in 1973 and 1979; the financial crisis in the beginning of the 1990s, the Asian crisis in 1997; the stock-market crash in 2001 and the credit/mortgage crisis between 2008 and 2009. The crises resulted in growing maturity debt levels in most of shipping firms (Kelly, Bengtsson, Lin, & Baker, 2016). Shipping companies have faced considerable losses after the crisis in 2008. For instance, Maersk Line lost approximately 2.1$ billion USD while around 20$ billion USD is recorded as the collective loss of other shipping carriers (UNCTAD, 2010). CSI, therefore, is sensitive to any change in global economic growth. Similar to many other industries, CSI has numbers of uncertainties. Even though there was a recovery in 2010, the unforeseeable and fluctuations cases such as the bankruptcy of Hanjin Shipping has created more uncertainties in the market which result in more difficulty in setting the prices. Essentially, increasing uncertainties go with more risks and make it harder to make the right decisions.

In short, the evolutions of CSI and the nature of shipping industry are developed with the VUCA concept: volatility, uncertainty, complexity, ambiguity. This acronym becomes more critical to consider in strategic shipping planning. The carriers have to consider the VUCA shipping environment and invest in information management, experimentations and predictions (Bennett & Lemoine, 2014). As a result, a strategic marketing plan for appropriate pricing decision is necessary for shipping firms. In order to set up a pricing strategy, shipping enterprises have to consider several elements that affect prices, especially the business forecasting and negotiating tools for pricing determination. A good pricing strategy is evitable to be better off in the VUCA environment, not only to challenge the changing environment and competition in the market but also to secure financial sustainability for the company.

1.1.2. The emergence of e-commerce in the container shipping industry

Today, digitalization and e-commerce trends are inevitable. There is evidences of the rise in sales, revenue and market volume in both top-performing economies and developing countries.

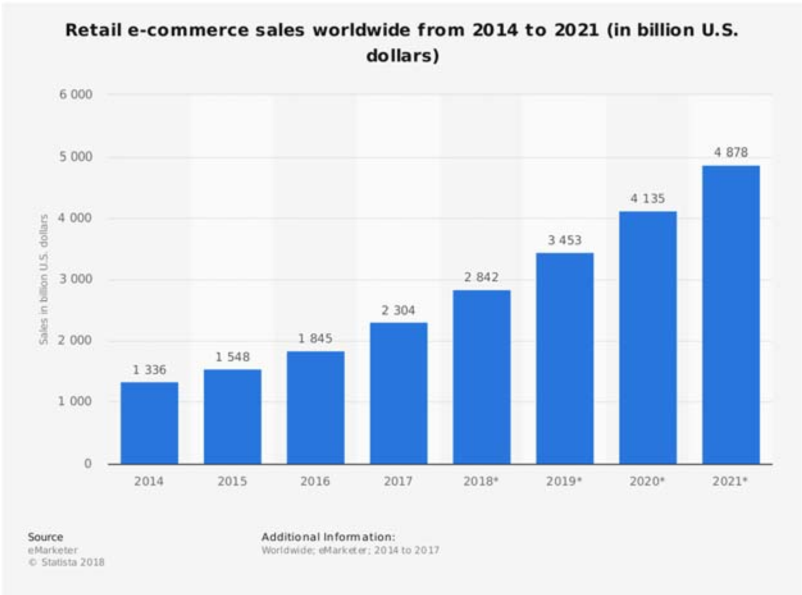


Figure 1. Historical and projected retail e-commerce sales worldwide between 2014 and 2021 (in billion U.S dollars).

Source: eMarketer. Statista (2018)

Figure 1 shows the information on worldwide sales by retail e-commerce between 2014 and 2021. In 2020, worldwide retail revenues are expected to reach $4135 billion USD and predicted to increase to 4878$ billion USD in 2021. As a result, e-commerce sales represent large revenues for businesses worldwide and are expected to have a steady increase trend.

Furthermore, with no signal of decline, there is a constant growth share of e-commerce in relation to its global share of retail, expecting 11.9% and 17.5% in 2018 and 2021, respectively (see Figure 2).

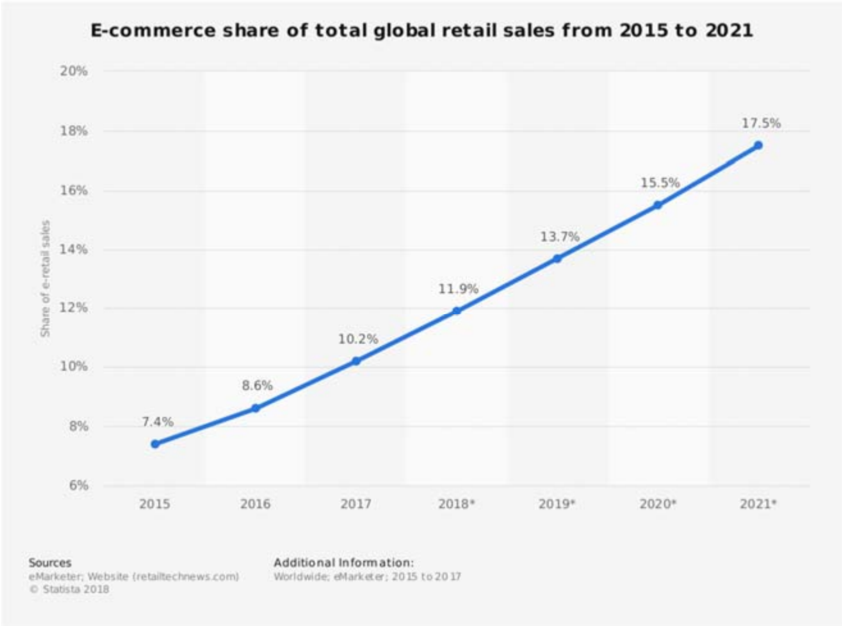


Figure 2. Share of e-retail in total global retail sales from 2015 to 2021

Source: eMarketer. Statista (2018)

E-commerce is increasingly shaping the business model in many industry sectors. Benefits of e-commerce include the monitoring of trade transaction and operations costs, the orientation of products and services through electronic interaction with customers, and as an assistance development of supply chain management. Communication technology devices and the availability of information are increasingly transforming competition patterns as well as reshaping the boundaries of industries.

E-commerce is defined by World Trade Organization as follows: “e-commerce is the production, distribution, marketing, sales or delivery of goods and services by electronic means" (WTO, 1998).

The Organization for Economic Co-operation and Development (OECD) defines E-commerce as follows: “E-commerce refers generally to all forms of transactions relating to commercial activities, including both organizations and individuals, that are based upon the processing and transmission of digitized data, including text, sound and visual images” (OECD, 1997).

The definition of e-commerce has been changing over the past 30 years. E-commerce originally refers to "the facilitation of transactions electronically". However, e-commerce still keeps its original function as supporting commercial transactions for goods and services in either intangible or tangible forms. The evolvement of e-commerce time by time in CSI is described as following: In the 1960s, big container shipping lines started to build up electronic databases with distribution systems on network platforms to control commodities, transhipment of goods and delivery operations, together with the purpose of making the most of resources through controlling empty containers. Over time, e-commerce aims to serve client's demand, as a public system platform when Internet becomes more and more developed. In the early 1990s, infrastructure and software costs, the lack of standards for electronic information exchange in the industry, along with the unwillingness to abandon paper-based commercial practices, they became obstacles to adopt e-commerce. In the late 1990s, when policy and legal issues, for example the governments were not willing to face e-commerce challenges and the legal issues related to electronic transactions became major obstacles to the use of e-commerce. Nevertheless, within a short time, e-commerce has become an effective tool which is used in CSI.

Conclusion.

Current shipping lines are confronted with a variety of obstacles in a competitive environment, for example, low freight rates but high fuel cost, clients' requests for safe shipment at a lessened cost and an ambiguous system unable to convey a concrete information flow. Especially, demand or shipping services and the ability to deal with cargo illustrates an apparent challenge. This is the reason why it is essential to have an automated and real-time tool to tackle these matters to assure that supply and demand can meet.

Operating models and digital technologies are as of now pushing shipping companies to team up with digital data suppliers. The business network is ready to widen their knowledge and capacities over the shadow of traditional marketplace activities. Advanced digital devices can improve shipping administrations and services by providing immediate, near-instant access to end customers, all with negligible transaction costs that can be eliminated to their shippers or freight forwarder. Most shipping liners acknowledge the importance of the end-to-end supply chain and have already embraced e-commerce with the target of completely automating shipping procedures, such as shipment booking, vessel plan, rate shopping, and documentation. While recognizing the significance of a web-based business, a number of shipping companies are implementing the platform gradually. A crucial challenge is overcoming the difficulties in business while keeping on track with the innovative advanced technologies. Building a fundamental IT foundation along with abiding by shipping regulations is also crucial for the emergence of technologies emergence in digital commerce.

1.2. Research objectives and questions

A container shipping companies need a scientific system or optimal pricing strategy to set the online direct price in order to increase profits. There are two main reasons. The first one is the inevitable trend of e-commerce in the CSI. The CSI has already entered into e-commerce emerging stage. In response to the development of e-commerce and advanced technology, several shipping companies and NVOCC have already established an e-commerce platform with an online channel. The development of the online channel has been encouraged by both the issues of e-commerce and spot rate shipping business. Customers desire to have a simple, easy to control, flexible and transparent system and technology to make it conceivable. As a result, shipping liners and freight forwarders expect a flexible network to meet an “on demand economy” with shorter contracts and spot rate demands. This pattern is enormously supported by the volatile nature of freight rates. The second reason is that the emergence of e-commerce in CSI has positive and negative impacts on all the CSI participants under different market conditions. If a container shipping company randomly sets the online direct price, this will definitely lead to conflicts between online direct and offline retail channels and damage the profits of the respective players in the supply chain.

The main objective of the dissertation is to propose the optimal online direct price for container shipping companies to maximize their profit in a dual-channel supply chain. The dissertation attempts to discuss and answer the following questions:

1. What are the factors influencing the pricing strategy and profits of container shipping company and NVOCC/freight forwarder in the decentralized dual-channel supply chain?

2. What are the Nash equilibrium results of optimal online direct and offline retail prices for a container shipping company and NVOCC/freight forwarder respectively in the decentralized dual-channel supply chain?

3. What are the implications of the Nash equilibrium results for a container shipping company?

(1) Has the online direct channel been fully developed for the container shipping industry to enter into e-commerce?

(2) If not, what are the reasons? Why only some container shipping companies have started to use online direct channel?

(3) How to promote the process of e-commerce in the container shipping industry?

4. What are the impacts of influencing factors' changes on the pricing strategy and profits of container shipping companies and NVOCC/freight forwarders?

1.3. Dissertation outline

In order to answer the questions proposed in chapter 1.2, the dissertation consists of 5 chapters and is illustrated as follows.

- Chapter 1: Introduction
- Chapter 2: Literature Review
- Chapter 3: Method
- Chapter 4: Numerical examples, findings and implications
- Chapter 5: Conclusion

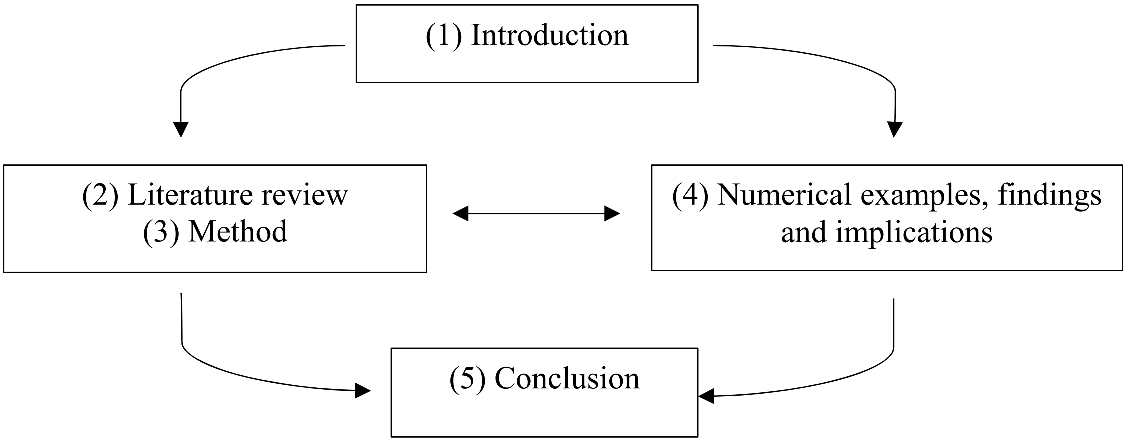


Figure 3. Research process and dissertation outline

Figure 3 presents a brief overview of the research process and dissertation outline. The rest of dissertation are arranged as outlined below.

In chapter 2, an overview of related articles and research is concluded to show the impacts of the online direct channel on pricing strategy and profits in CSI. The following questions are discussed in chapter 2: What has been studied and developed by previous scholars in literature and research regarding the topic? What is the gap between the current study and questions for our topic? What is the innovation of the dissertation in order to solve the questions listed in chapter 1.2.

In chapter 3, the Nash equilibrium results of online direct and offline retail prices for a container shipping company and NVOCC/freight forwarder are derived through models' construction and optimization. The following steps are used to construct the profit models for a container shipping company and NVOCC/freight forwarder. Firstly, the factors that influence the pricing strategy and profits in the dual-channel supply chain are discussed, and part of them are selected as inputs of the models. Secondly, the model framework is constructed to clarify the objectives, inputs, assumptions and output of the profit models. Thirdly, the consumer utility functions are used to derive the profit models for a container shipping company and NVOCC/freight forwarder. After constructing the profit models, the Nash equilibrium theory is used to find the optimal online direct and offline retail price for a container shipping company and

NVOCC/freight forwarder in the decentralized dual-channel supply chain. In short, the first and second questions listed in chapter 1.2 are answered in chapter 3.

In chapter 4, several numerical examples are implemented and their implications for container shipping companies are concluded. In order to make sure that this dissertation is useful and applicable to the CSI, the independent variables with reference to real data from an international shipping company are used. Sensitivity analyses of independent variables is conducted through numerical examples. The effects of independent variables' changes on pricing strategy and profits are discussed in-depth. Moreover, the findings and implications are also summarized correspondingly. In short, the third and fourth questions listed in chapter 1.2 are answered in chapter 4.

Chapter 5 draws the conclusion. The highlights and the limitation are concluded in this section.

Chapter 2 : LITERATURE REVIEW

This chapter presents some definitions which are used in the dissertation and numbers of related studies about dual-channel supply chain management and pricing strategy. Hence, it explains the gap of the previous related research and introduces the contribution of this dissertation to dual-channel supply chain study.

2.1. The impacts of e-commerce on container shipping industry

The rapid development of e-commerce in CSI is explained with its evolution through the years together with its impacts on the stakeholders. The current use of e-commerce in the shipping industry is also presented.

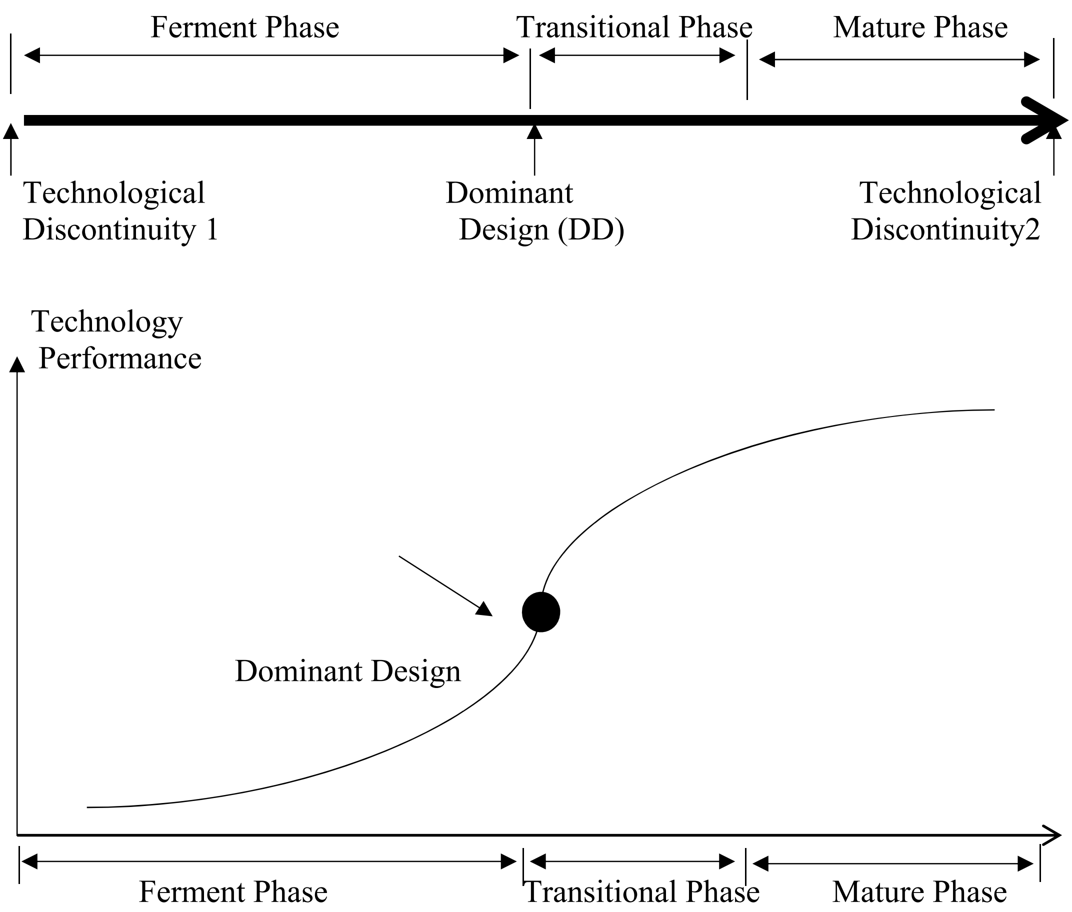
2.1.1. E-commerce evolution in the container shipping industry

The framework of technological evolution is described by Auh (2003) with two critical concepts: technological discontinuity with 3 phases (ferment, transitional, and mature phase) in Figure 4.

The technology discontinuity is the point when a new revolutionary technology is introduced and replaces the current technologies. Since then, new industry dynamics are established and the competition in the industry is entirely followed by a variety of accomplished “product innovations”. Numbers of new founded companies will join the market with product designs and compete with each other and/or with the industry bearers in compliance with the product capabilities. Many companies grow in this period of time which is called the “ferment” phase. When the companies have more knowledge of the demands for the product, the gap between new products shrink. Hence, a “dominant design” appears with a collection of product’s basic technical functionalities which is accepted among the industry participants.

The transitional phase comes after the ferment phase when the dominant design emerges. This period also goes with a substantial sudden decrease. The transitional phase is intrinsically shorter than the ferment phase. Additionally, the number of firms in the transitional phase is estimated to drop 50% compared to the ferment phase.

When the companies within the industry are stabilized with the increasing number of consolidations among companies, the mature phase appears. In this phase, the innovation emphasizes not only the product itself but also the process of manufacturing. The enterprises in this phase compete with prices rather than product quality. The product with an agreed upon standard from the industry participants is substantially commoditized. The product is also complemented with distribution channel, reputation, brand to promote its value, hence it becomes more competitive in the market. The complementary assets to the product are established during the ferment and transitional phases which create the barriers for the new entrants.



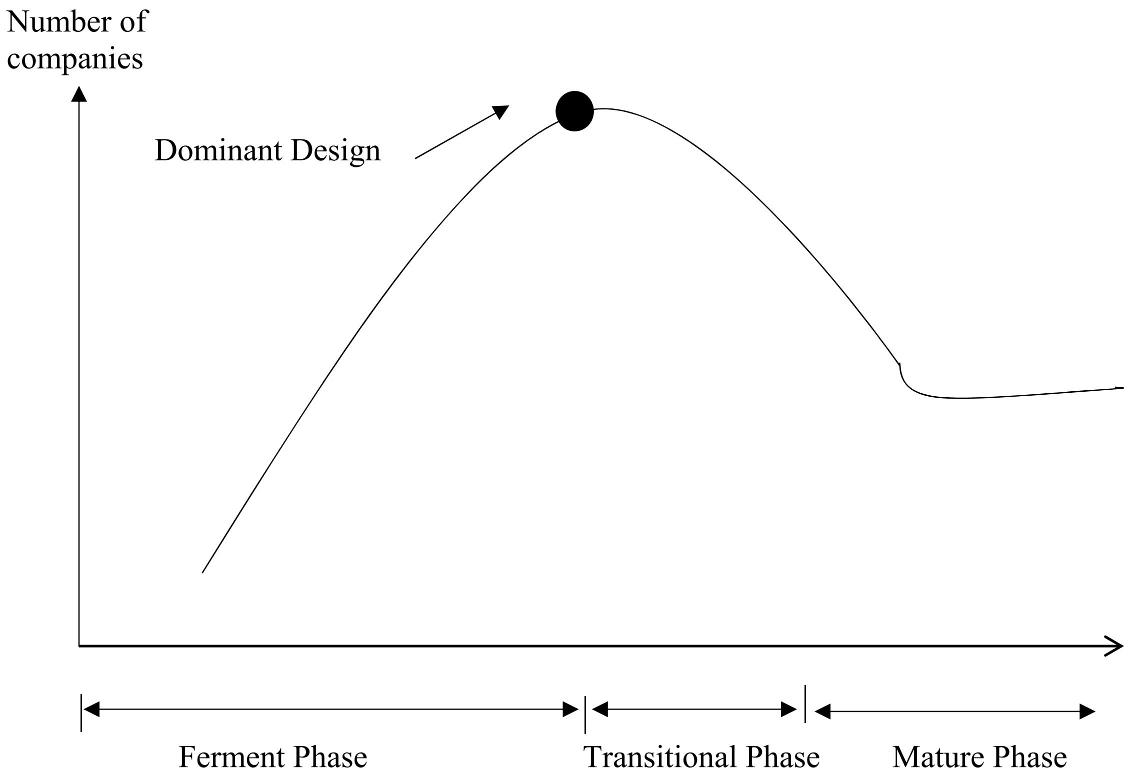


Figure 4. Technology evolution framework

Source: Auh (2003)

Technological evolutions in the CSI was described by Auh (2003) with 4 adopted major technological innovations: containerization, intermodalism, the double-stack train (DST) system, and EDI connections. E-commerce in this dissertation is considered to be the next innovative technology which drastically affects CSI.

Container shipping lines and shippers uniquely benefits from technological innovation but through the years, the technological innovation turns to be commoditized. There are no exclusive rights for the innovations in CSI which allow new entrants to make use of innovations. They pay no substantial premiums to the innovators. E-commerce emerges in CSI slowly and have been taking advantage of the benefits of all stakeholders for mutual industry benefits.

The combination of the development of CSI and the framework of the technological evolution is explained as follows:

- The “technological discontinuity” in maritime shipping industry is when the container shipping service was first introduced in 1956. Literally, in the framework of technological evolution “containerization” is equal to “technological discontinuity”.

- Containerization was followed with a range of “product innovations” including intermodalism and the DST systems. Technically, intermodalism and the DST systems concentrated on improving efficient logistics services.

- “Dominant design” in CSI emerges with a consolidated functionalities of container shipping services such as shore-based container cranes, the standardized containers, intermodal connections to implement door-to-door container shipping services and hub-and-spoke system.

- Electronic Data Interchange (EDI) followed up as “process innovation” after the agreed upon by industry participants with dominant design. Without revising the basic layouts of container shipping services, EDI considerably supported to enhance the information process of container shipping. Furthermore, current internet-based business activities focus on enhance the process of container shipping service rather than the product. The presence of e-commerce in this point marks the innovative technology in improving process of container shipping service together with EDI.

- In the context of technological evolution, CSI is currently in the mature phase. Therefore, there are high barriers for the new entrant to join forces due to capital-intensive requirements and for the players to exit the industry as well. The complementary assets including reputation, brand, distribution-channels critically requires competent management (see Figure 4).

Importantly, the container shipping service is substantially commoditized. which leads to the low profitability of container shipping services. An efficient cost management and a proper pricing strategy are important for competition – a strategic plan for the success.

2.1.2. The impacts of e-commerce to the stakeholders in the container shipping industry

E-commerce considerably impacts transport services in many aspects. Firstly, it creates more demand on transport services. The customers in liner shipping are generally divided into two types, namely scattered customers and contract customers. The container shipping companies have to deal with an increase of scattered customers through online booking thanks to the development of e-commerce. As a result, the stability and predictability of booking slots is enhanced. In addition, these customers are not as sophisticated as the contract customers. Liner shipping companies, therefore, have to establish a cutting-edge set of supply chain to the clients with diversity of shipment origins and destinations or a greater responsiveness. Secondly, the demands of the customer on the following day or even the same-day of delivery requires shipping companies to not only to be ready to ship but also to maintain the slots across the scheduled vessels. Fortunately, the shipping industry does not have to suffer inventory cost. However, shipping companies will have to review the network of vessel's slots and ensure the in-time delivery for the shipments that the customers booked regardless of whether container is full or less. This pressures the container shipping companies about infrastructure and management plans.

E-commerce promotes transportation exchanges as it proposes more options for Internet-based transaction. This stimulates the competition among carriers in transportation services supply. Theoretically, all the carriers can approach the demand of worldwide cargo transport. The competition, therefore, turns out to be a disadvantage for small carriers with incompetent services. On the other hand, e-commerce improves the capability of shipping companies to control and manage the whole transportation chain, which results in an enhancement in the chain's performances. Furthermore, this will promote the emergence of dominant shipping companies through merges or vertical integration against competition.

Regarding to the cargo owners, the transportation services, which are offered with the Internet-based transportation system, assist the cargo owners to access the order through enterprise resource planning system. The order will automatically be sent to the carriers' transportation management system. This system will regulate and accept the price, concede the order, convey the messages about pick up of the shipment, inform the consignees and carrier and pay for the carrier's charges. The cargo owners have to access one website and possess customized overview of the shipment in transit, shipment status, deviation reports, pick-ups arrangements and up-to-date freight rate across the routes. E-commerce creates a better partnership among cargo owners and carriers by providing a direct contact between them. This reduces the monopolies in transportation services that influence the service price. Cargo owners and container shipping lines may rely on confidential price negotiations and contracts for better pricing. Individual contracts can be made in some major trade routes for liner shipments.

E-commerce decreases the importance of traditional freight forwarders and other intermediaries. In response to the increasing demand of their services, several intermediaries have developed new business models, for instance value-added logistics services, and improved the capacity of door-to-door services. Intermediaries are attractive because of their specialized knowledge of and experience in a variety of issues including packing, warehouse, formalities and documents, customs and transportation. The cargo owners can look for know-hows with issue-related information online; however, the wide variety of services that are offered by forwarders are exclusive to continue to enjoy.

Today, cargo owners have better choices than ever before to discover prices and engage in instant transactions. The carriers have considered NVOCC, freight forwarders or other shipping lines to be competitive threats, they now have to face the fact that shippers can access price tools to make quick procurement decisions. One of those tools are freight rate marketplaces, which are the model of digital freight forwarders that can be easily used to have quick quoting interface, and the establishment of freight forwarding companies who launched instant quotation and booking platforms that are suitable for their NVOCC business. If the shipping lines aim to bring shippers to an online quotation environment, it is neccessary to invest in such tools. Moreover, they have to get rid of a long-time culture of rate opacity into transparency. One apparent example is when the customers looks for quoting or booking directly from the shipping lines. The customers have to use several mouse clicks to request a quote. Some online systems have areas to search directly for sailing schedules in the homepage. However, the shipper faces difficulty in receiving immediate quotes even though they accessed to request quotes from electronic forms. The customers are then frustrated and find other alternatives with better providers. Thus, at present, there is a few proportion deals by online channels, and the shipping companies do not pay more attention to the pricing strategy. According to the studies of supply chain coordination in the dual-channel, the dual-channel cannot ensure the increase of manufacturers' profits and there are conflicts between two channels. Only through appropriate analysis and coordinated contract design, the whole supply chain profits can be improved.

2.1.3. Current use of e-commerce in the container shipping industry

(1) Sell-side e-commerce

Sell-side business in e-commerce refers to a number of clients access a single firm's website to purchase products with specific prices (see Figure 5). Sell-side e-commerce is a distinct chance for shipping lines when the container slots on the ship can be considered as a standardized commodity. The perception works well with regular bookings, but in some cases such as peak demands, special containers or last-minute bookings it is difficult to tackle.

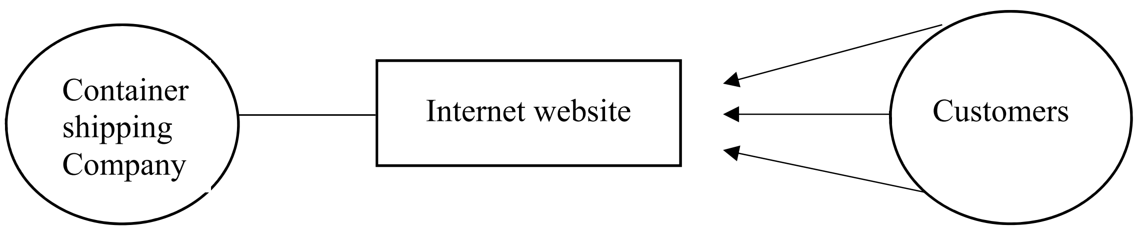


Figure 5. Sell-side in e-commerce

Source: Van Ham & Kuipers (2004)

Although the 12 largest worldwide container companies account for 85% of the world's shipping containers, CSI is still quite far from reaching shippers through e-commerce tools. For example, there are only two major container companies in the world, Maersk and Hapag-Lloyd, which allow shippers to access actual rates through the ordering tool as shown in Table 1 as below.

Table 1. Carrier instant quote capability

Source: Johnson (2018)

	Instant Quote Tool	**Quote for Available**	**Shipping Schedules Available***
Maersk Line	√	√	√
Mediterranean Shipping Co		√	√
COSCO		√	√
CMA CGM	√	√	√
Hapag Lloyd	√	√	√
ONE			√
EverGreen Line			√
Yang Ming			√
PIL			√
Huyndai			√
ZIM		√	√
WanHai		√	√

*no electronic quoting available

Most of the digitalization in shipping companies, from an operational or customer-related perspective, is concentrated in these biggest 12 companies. The current small and medium-sized companies do not have enough capacity to develop their online sales system to engage with their customers. With most of the top 12 container carriers, the customers have to keep in touch through email or electronically for rate inquiries. Five out of twelve have no electronic quoting system to respond to electronic rate requests. Only three container lines among the top 12 offer instant quotes for customers while the others require the clients to submit the electronic rate requests. The notable e-commerce tools from the container shipping lines are Maersk Line with ship.maerskline.com and my.maerskline.com tools; CMA CGM with e-Business suite, Hapag-Lloyd's QuickQuotes tool. However, all the platforms require the clients to register with username and passwords. Moreover, the most carriers have practically no direct quoting or booking widget on their respective home pages. They locate in the "e-services" tab in the menu tools and require a number of clicks to request a quote. Many platforms demonstrate the search for sailing schedules from the homepage which linked with a possibility for direct booking. Besides, more than half of the top 12 container lines have created the functionality for rate quote requests via electronic form but hardly ever receive instant quotes (Johnson, 2018). This reflects a long way for clients to make use of e-commerce tools while they are more popular in other industries. The questions are posed among the stakeholders, especially the small and medium sized companies, about whether the carriers are keen on business transaction with online quoting platforms.

(2) Buy-side e-commerce

Buy-side business in e-commerce refers to the ability to enter and purchase the orders from one client to different numbers of companies (see Figure 6). A wide range of companies can handle the order and bid each other for the best offer. The customers benefit by using the platform while the sellers have better chances of receiving large orders. E-commerce has moved from product-orientation to customer-orientation. In the shipping industry, freight forwarders and cargo-owners can take advantage of this strategy because there are limited affordable sellers in this e-commerce market. The products in this case are volume, time, and weight with high price.

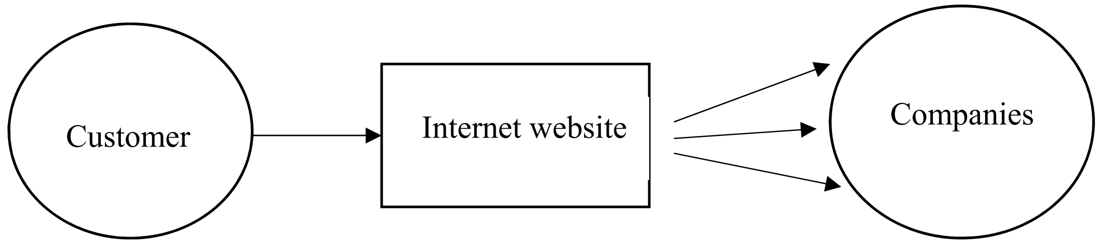


Figure 6. Buy-side in e-commerce

Source: Van Ham & Kuipers (2004)

When the information and communication technology is more advanced, more companies concentrate on implementing e-commerce. There is an increasing number of companies entering into the shipping industry with e-commerce as a tool. While several of them are container shipping enterprises, the others are air and inland transport enterprises. NVOCC can also emerge into the e-commerce system and the cargo owners can also require information from the third-party infomediaries thanks to the e-commerce system.

In April 2000, five shipping lines in CSI, including MSC Mediterranean Shipping Co., Maersk-Sealand, Hamburg Sub, CMA CGM and P&O Nedlloyd, launched a B2B Internet portal. It is a big leap to invest in the transportation portal on the Internet. As a result, an e-commerce platform, namely INTTRA, was introduced in 2001 as an initiative. None of the investors have the majority shares of the company as it is a neutral one. It presents an organizational variant of a virtual web with district characteristics led by a steering committee. Kuehne-Nagel and Hapag-Lloyd later also joined forces. Moreover, INTTRA welcomes non-ocean carrier participants with some fees. At the end of 2001, INTTRA was supported by 12 major shipping companies and served over 42% of the ocean-going transportation market. To be more specific, INTTRA at that time had over 1400 registrants from 400 companies in 50 countries controlling over 60,000 containers and 35,000 bookings (Ham & Kuipers, 2004). Due to the sponsorship from major carriers, freight forwarders, shippers and consignees are not charged for accessing the service while the shipping companies have more savings with all availability of event information, schedules and bookings via the software.

Shippers benefits from INTTRA as a single integrated process for all activities from booking, tracking and tracing commodities from numbers of carriers. The customers can interact in the platform through different communication channels via Internet, phone and email. Furthermore, an online sailing schedule are essentially available with thorough information about vessel/slot availability, date of departure/arrival, list of terminals/ports, total transit time together with options for shipping alerts and instructions, contract and report management. INTTRA, hence, is an innovative web-based partner portal as a variety of stakeholders work closely in a system. Besides, large shipping companies currently prefer to have their own platform on their respective official websites. For example, Maersk, CMA-CGM and Hapag-Lloyd built their own platform for promoting e-commerce with business transaction by themselves. Despite the fact that e-commerce is slow to access into container shipping companies, e-commerce in CSI faces limited customer preferences. The customers lack knowledge of IT and get more challenges to struggle with the platform functions. They tend to prefer the traditional way to look for the intermediaries for better support.

2.2. Pricing strategy in dual-channel supply chain

The dual-channel has a variety of impacts on the profits and decisions of manufacturers and traditional retailers. With the e-market place environment, the inter-base global market is opened to everyone and everywhere, which allows the manufacturers to have direct approach to the customers and affects the benefits of traditional retailers. An unreasonable pricing strategy in the dual-channel supply chain can result in the clashes among the channels, hence, pricing problems are one of the key matters in the dual-channel supply chain.

2.2.1. Dual-channel supply chain and pricing strategy

(1) Dual-channel supply chain

With the emergence of e-commerce, customers are getting familiar with online direct channels. By using online channels, the companies can handle the orders and arrange the logistics service timely. A number of manufacturers face the challenge of setting up a direct selling channel parallel with the existing traditional channel. It derives with the fact that the supply chain has offline (traditional retail) with the presence of retailers and the electronic (direct sales) channels thanks to the Internet-based system. Li (2018) explained the phenomenon in his paper, ie the development of both online and offline channels is called dual-channel supply chain. Figure 7 explains the stakeholders in dual-channel supply chain.

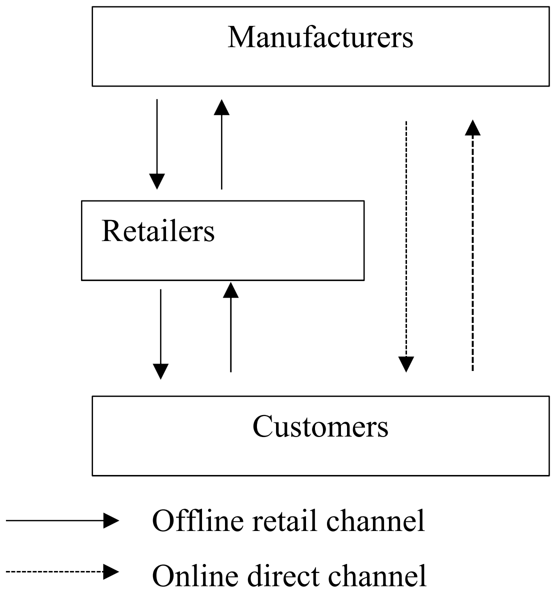


Figure 7. Dual-channel supply chain

Source: Li (2018)

The rapid development of advanced technology has promoted research on dual-channel supply chain management. Chiang, Chhajed and Hess (2003) has studied that a manufacturer who make use of online sales channels not only boosts their profits but also reduces their costs compared to traditional sales channels. Fruchter and Tapiero (2005) studied the problems of dual-channel distribution from consumer perspectives by taking advantage of multiple regression analysis and structural equation modeling. The research shows that online sales channel cannot replace traditional sales channel, consumers prefer both sales channels. Szmerekovsky and Zhang (2009) analyzed the decision-making issues of both manufacturers and retailers in advertising activities. Luo, Li and Zhang (2014) studied the profit and service of all the stakeholders in dual-channel supply chain, the effect of "bidirectional free-riding" on the pricing and the conditions for manufacturers before setting up any direct online network. Huang, Yang and Zhang (2012) showed that customers' demand changes and preferences affect manufacturer's production strategy as well as retail price strategy. Liu and Zhang (2006) found that retailers will make use of price discrimination to oppose manufactures who develop a direct sales system to benefits retailers. Research on dual-channel supply chain have emphasized on the decision-making, the conflict among channels in dual-channel supply chain, the coordination mechanism in the dual-channel supply chain and more importantly, pricing strategy of dual-channel supply chain.

When studying on dual-channel supply chain, the supply chain is divided into two groups: centralized and decentralized supply chains. In the centralized supply chain, the whole supply chain is dominated by manufacturers or retailers. All participants in the supply chain make their own decisions based on mutual trust, sharing of information, and maximizing the overall interests. The purpose of such centralized supply chain is to minimize the total cost or maximize the total revenue of the supply chain as a whole. In the decentralized supply chain, there is a game relationship among participants. All participants in the supply chain make decisions independently with the goal of minimizing their own costs or maximizing their own benefits. Zhengping and Yezheng (2013) concluded that the equilibrium price of decision-making in decentralization is different in dual-channel structures. When free-riders exists, equilibrium price exists in a decentralized supply chain and a prompt pricing strategy is proposed to maximize the overall supply chain's profit. Modak and

Kelle (2019) presented that the centralized channel system produces more profit than the decentralized one. The optimal online delivery lead time in the centralized supply chain is also higher than that of the decentralized supply chain. With the reduction of online lead time sensitivity, the manufacturer should reduce the retail lead time because of the low return rate with the outgoing unsatisfied customers. Zhang and Wang (2018) examined the static and dynamic pricing model in both centralized and decentralized decision models and propose a two-part tariff contract under the long-term price forecasting mechanism. Ranjan and Jha (2019) examined decision models in developing green quality and sales effort for optimal performance in the supply value chain. This research also took advantage of the Stackelberg game to achieve the optimal results of decentralized and centralized models. Generally, the centralized model essentially gave the most supply chain profit and assisted in achieving economic targets. Dual-channel in supply chain has been studied in a great deal of research under both the centralized and decentralized mechanism.

In short, manufacturers can comprehend the needs of customers through the direct sales channels and predict the market demand more accurately accordingly. This enhances not only profitability but also customer satisfaction. Consequently, manufacturers are motivated to participate in the market by implementing dual-channel supply chain which creates more competition in the market. However, retailers are against manufacturer's online sales system. They argue that online channel directly threatens traditional retail channels, rendering the conflict between dual-channel supply chains more noteworthy. This makes the impact of dual-channel supply chain management more difficult and it leads to the failure of dual supply chain operations.

The impact of opening online channel in the dual-channel essentially are examined in a numbers of research fields. Dual-channel cannot make sure definite profits increase for manufactures; channel conflicts exist and affect many issues for both the manufacturers and the retailers (Tsay & Agrawal, 2004). The impact of online direct channel has attracted a lot of attention throughout the years. Webb (2002) showed that online sale channel can decrease conflicts among channels via brand diferentiation and reasonable pricing strategies. Chiang, Chhajed and Hess (2003) argued that the development of an online sales system can increase the ability of manufacturers to manage the prices of retail stores. Park and Keh (2003) demonstrated that manufacturers who choose online sales are financially benefited because dual supply chain management improves efficiency and overall performance. Cattani, Gilland, Heese and Swaminathan (2006) argued that manufacturers can effectively benefit both customers, manufacturers and retailers through proper pricing. Cai, Zhang and Zhang (2009) pointed out that a suitable price strategy and price promotion can reduce conflicts between channels, and improve the overall efficiency of the supply chain. Guo and Zhao (2008) studied the causes of conflicts in dual-channel supply chains and how to coordinate the two channels through the use of the consumer utility theory. Yan and Pei (2009) argued that the manufacturer's network of direct sales channels could improve the services of traditional retail stores, reducing market wholesale prices and promote the profit sharing. Chen and Liu (2010) argued that service competition in dual-channel supply chain assists dual-channel supply chain to be better than the single-channel supply chain. Especially when customers tend to prefer online sales channels, the profit from dual-channel supply chains increases Chen, Zhang and Sun (2012) pointed out that the direct selling system not only helps producers to reduce costs and increase profits, but also avoids the management of traditional chain stores costs. All of the studies show that the opening of online direct channels will have positive and negative impacts on manufacturers, retailers and consumers under different assumptions and constrains, which emphasize the importance of using appropriate pricing strategies to allow for the use of dual-channel supply chain.

(2) Pricing strategy

The pricing concept is more popular in business and has become one of the six pillars structure to get the highest value from the customer segment and gain the highest profitability (Deloitte, 2017). The six pillars are pricing strategy, advanced analyses and pricing, technology and data management, price execution, corporate governance and alignment, and tax and regulatory effectiveness. Pricing strategy is defined by Deloitte as an efficient strategy that is promoted for business goals in order to take over the value compared to competitive alternatives and the demand of the customers. A comprehension of market dynamics which is established from the product nature, customer information and distribution plans are the framework for the pricing function from a fully decentralized to a fully centralized model. Therefore, in order to make the business grow, one of the excellent strategies is how to price the services. Pricing is among the strongest profit lever in the industry which is full of susceptibility and complexity. Montan, Kuester and Meehan (2008) showed that an effective price management can yield approximately 2 to 7% higher margins in 12 months and increase the return on investment to 200 to 350%. Nevertheless, a number of companies have not focused on their price strategies in dual-channel supply chain because these shipping companies have little vision of their companies' operations and understanding of the profits of their channels, assets and customers.

Many recent researches on dual-channel supply chain tends to concentrate on pricing strategies. Webb and Lambe (2007) argued that price differences between channels could be managed within the proper range through price corridors to recognize price differences in the channels. Cattani, Gilland, Heese and Swaminathan, 2006 pointed out that in order to minimize conflicts between channels, there should be a price strategy set out in the direct sales channel in line with the retail price of traditional sales channel. Kurata, Yao, and Liu (2007) included price determination in the environment where competition between sales channels and brands coexists. He figured that wholesale prices subsidy contract is an effective way to coordinate the supply chain. Dumrongsiri, Fan, Jain and Moinzadeh (2008) emphasized the quality of services and addressed the conditions for manufacturers to participate in sales channels and price strategies for dual-channel supply chain. Hua, Wang and Cheng (2010) showed that the optimal price and time can be studied through two perspectives: concentration and decentralization. Li, Hou, Chen and Li (2016) considered dual-channel supply chain with a risk-averse retailer and a risk-neutral supplier and recommended risk-sharing contract to ensure a win-win outcome of the members in supply chain. Zhou, Guo and Zhou (2018) investigated pricing strategies in the dual-channel supply chain with service-cost sharing and free-riding. He emphasized that the effect of free-riding in dual-channel in differential and non-differential pricing scenarios, especially, when the manufactures' online channel free-rides the retailer's pre-sales services. Zhang & Wang (2018) investigated two dynamic pricing strategies in dual-channel supply chain with service. He argued that different pricing strategies will result in a disparity in stakeholder's profits and calculated that the fixed fee changes when service value increases. Ranjan and Jha (2019) studied the coordination mechanism and pricing strategies in dual-channel supply chain with Stackelberg game-theoretic approach. He examined 3 models (collaboration, centralized and decentralized) when the manufacturers offer non-green product in offline retail channel and eco-friendly products in direct-channel. Dai, Wang, Liu and Wei (2019) investigated pricing strategies in dual-channel supply chain when the retailer concern about fairness and take advantage of Stackelberg game approach to determine the equilibrium solutions among the parameters relating to cross-price sensitivity and fairness.

Many researchers have studied pricing strategies in the dual-channel with specific conditions under different products strategies and channel structures. All the mentioned researches about dual-channel supply chain and pricing strategies have shown that pricing strategies is crucial to coordinate channel conflict and allocate channel profits. In dual-channel supply chain, channel conflicts and price competition require the stakeholders to pay attention to profit's distribution. This paper therefore attempts to applies the pricing strategy in the dual-channel supply chain into CSI.

2.2.2. Game theory-based pricing strategy

Game theories is widely used in pricing strategy in the dual-channel supply chain, especially the Stackelberg theory and Nash equilibrium. The game theory has been taken into consideration to study the interactions among a number of actors in the supply chain (Hennet & Arda, 2008).

The Stackelberg theory is used to analyse the dynamic game of the decentralized supply chain. Both sides in the supply chain are independent in decision-making and they aim at minimizing their own costs or maximizing their own benefits. The economist H. Von Stackelberg (Stackelberg, 1952) first introduced the Stackelberg game theory in 1934 in a static competition games context. Since then, this game theory tool has had considerable impacts on economic sciences. In this model, the followers observe the move of the leader's strategic actions and start to react for profit maximization. In the dual-channel supply chain, Stackelberg includes manufacturer-lead and retailer-lead. They are applied depending on the characteristics of the specific market and industry. A hierarchical structure between players and the decisions are made at different hierarchy's levels. The interactions between the players in this discussion follows the structure of a Stackelberg game. There are two level-decision issues, which are known as bilevel optimization program and a leader-follower relationship among the participants. In this sense, Stackelberg game between two players is used to involve in processing and selling services. The fundamental obstacle in the model is to support the integration and coordination of information and activities among two agents. The pricing strategy is discussed when the retailer offers value added services and fairness concerns in dual-channel supply chain by the application of Stackelberg game (Qing-Hua & Bo, 2016). The dual-channel supply chain can be coordinated by the retailer's profit share with the assumption that manufacturers acts as Stackelberg leader (Jing, Hui, & Ying, 2012). The impact of advertising investment on the pricing strategy is also studied with the application of Stackelberg game in a dual-channel supply chain (Huang, Yang, & Zhang, 2011). The Nash equilibrium and Stackelberg equilibrium are both discussed with price discount contracts between manufacturers and retailers (Gangshu Cai, 2009). Thus, research on the dual channel supply chain also makes use of both Stackelberg and Nash equilibrium for pricing strategy in their studies such as Lu and Liu (2013), Radhi and Zhang (2018) and Taleizadeh, Alizadeh-Basban and Sarker (2018).

Nash equilibrium is the concept of game theory in which "the optimal outcome of a game is where there is no incentive to deviate from their initial strategy" (Kopalle & Shumsky, 2012). In other words, hypothetically when the other opponents stay the same with the strategies, the player has no increasing benefit from changing his action.

One game can have many Nash equilibrium or none of it. The Nash equilibrium is in the game with more than two strategic players where the players take consideration of the opponents' choices. The Nash equilibrium is achieved when the player has no incentive to switch his strategy considering the other participants' decisions. All the players achieve a win-win situation. Recent researches have successfully applied this game theory as a common methodology in coordination between stakeholders and pricing strategy in supply chain management (Zhang, Wang, & Wang, 2016; Zhao, Atkins, Hu, & Zhang, 2017; Chen et al., 2018; Radhi & Zhang, 2018). For example, Chen et al., (2018) studied reserve logistics with an environmentally conscious customer in the green supply chain. By comparing two pricing strategies in three different game models, he concluded that customer environmental awareness positively impacts revenues.

2.2.3. Consumer utility theory-based pricing strategy

Demand functions are the basis for derivation of profit functions. The consumer utility functions are widely used to derive demand functions in the dual-channel supply chain. The consumer utility theory is applied to deduce the demand function, based on which pricing strategy of the manufacturer in the dual-channel supply chain is put forwarded (Cattani, Gilland, Heese, & Swaminathan, 2006). Moreover, whether the manufacturer should adopt consistent pricing is discussed too. The pricing strategy with consideration of product characteristics, consumer preference and consumer utility theory is studied (Dumrongsiri, Fan, Jain, & Moinzadeh, 2008). In addition, the research shows that the supply chain system has an equilibrium solution only when the sales cost on the retail channel is in a certain range. Chen, Kaya and Özer (2008) applied the theory of consumer utility to study the two-channel pricing strategy under service competition. The service level of manufacturer's direct channel is determined by the delivery time, and that of the retailer's traditional channel is determined by the service level of the manufacturer's direct channel. Moreover, retailers are compared with each other to illustrates that retailers in the dual-channel supply chain have more advantages. With the application of the consumer utility theory, the impact of Internet channel entry on the channel members are studied deeply under various mixed channel structures (Yoo & Lee, 2011). The consumer utility theory is found in a great deal of recent research on the supply chain (Li, Chen, Xu, & Hou, 2018; Wang, Leng, Song, Luo, & Hui, 2019).

2.3. Pricing strategy in the dual-channel supply chain in the container shipping industry

Container shipping enterprises have been keen on using pricing as a profit lever. Cost-plus pricing is traditionally ingrained in the industry, which currently becomes ineffective due to the volatility nature of shipping market. The market keeps raising; however, industry players have become more cautious with little capitalization on this growth. Shipping companies struggle to alter their rates in accordance with market fluctuations or immediately innovate priced offers to their services' portfolio. Several shipping companies have coped with the challenges by cutting costs. However, cost cutting allows for small financial gains with every rounds of the cuts. Eventually, additional cuts reach a point where they become ineffective. Therefore, shipping companies have considered to change their strategy from cost cutting to growth. Growth is challenging when the market is full of uncertainties; nevertheless, opportunities lie in every proper strategy. There are a few articles concerning the pricing strategy in CSI with focus on the revenue management in the pure offline retail channel. An analytic discount model with single or multiple price-break points has been designed to maximize the carriers' and forwarders/NVOCCs' profits (Yin & Kim, 2012), and numerical experiments have been made to verify the effectiveness of the quantity discount schemes. A fundamental revenue management model concerning capacity control and pricing models was developed for CSI with the reference to the revenue management application for air transportation (Meng, Zhao, & Wang, 2019). Most scholars as a result do not pay enough attention to impacts of the online direct channel to the pricing strategy under the dual-channel selling structure in CSI. There are just two articles concerning the dual-channel supply chain in CSI, and both of them focus on the optimization of slot allocation. One of them addresses the issue and tries to optimize the slot allocations in the dual-channel supply chain (Hu, Li, & Yang, 2016). The optimization of slot allocation for container shipping companies is discussed under e-commerce environment (Hu, Huang, & Zhao, 2019). It is concluded that the total revenue of a container shipping company can be improved through the improvement of online predictability and stability.

2.4. Summary

The gaps between the current studies and questions are summarized as follows: (1) There is no quantitative research concerning the impacts of e-commerce on the stakeholder in CSI. Most of the articles only discuss the impacts qualitatively. (2) There is no research concerning the pricing strategy for container shipping companies in the dual-channel supply chain.

The dissertation innovates to address the gaps about applying the pricing strategy in the dual-channel supply chain in CSI and discusses the impacts of e-commerce in CSI quantitatively; some of the previous mentioned theories are used in the dissertation.

(1) Only the decentralized dual-channel supply chain is discussed due to the reality in the current CSI. Container shipping companies and NVOCC/freight forwarders do not cooperate with each other with regard to online and offline pricing. They only aim to maximize their own profits, not the profit of the whole supply chain.

(2) Nash equilibrium theory is applied in the dissertation considering the market characteristics in CSI. The authors assume the wholesale price is decided by the market because CSI is regarded as an oligopoly market (Rau & Spinler, 2016; Sys, 2009). Therefore, container shipping companies and NVOCC/freight forwarders are assumed to set the online direct price and offline retail price separately, respectively, and separately at the same time. Furthermore, they comprehend each other's best strategy before taking actions. There are no leader and follower between container shipping companies and NVOCC/freight forwarders.

(3) The consumer utility theory is also applied in this dissertation to derive the demand functions to construct further models.

Chapter 3 : METHOD

In this section, the factors that influences the pricing strategy and profits in the dual-channel supply chain are discussed. Then, a conceptual dual-channel supply chain in CSI and model framework with objectives, inputs, outputs, and assumptions are established. In addition, the prices and profits models for container shipping companies and Non-Vessel Operating Common Carrier (NVOCC)/freight forwarders in the conceptualized supply chain are constructed. Finally, the existence of optimal online direct price, optimal offline retail price and Nash equilibrium results are verified, and the equations of optimal online direct price, optimal offline retail price and Nash equilibrium results are derived. All the steps of model construction and optimization are illustrated in Figure 8.

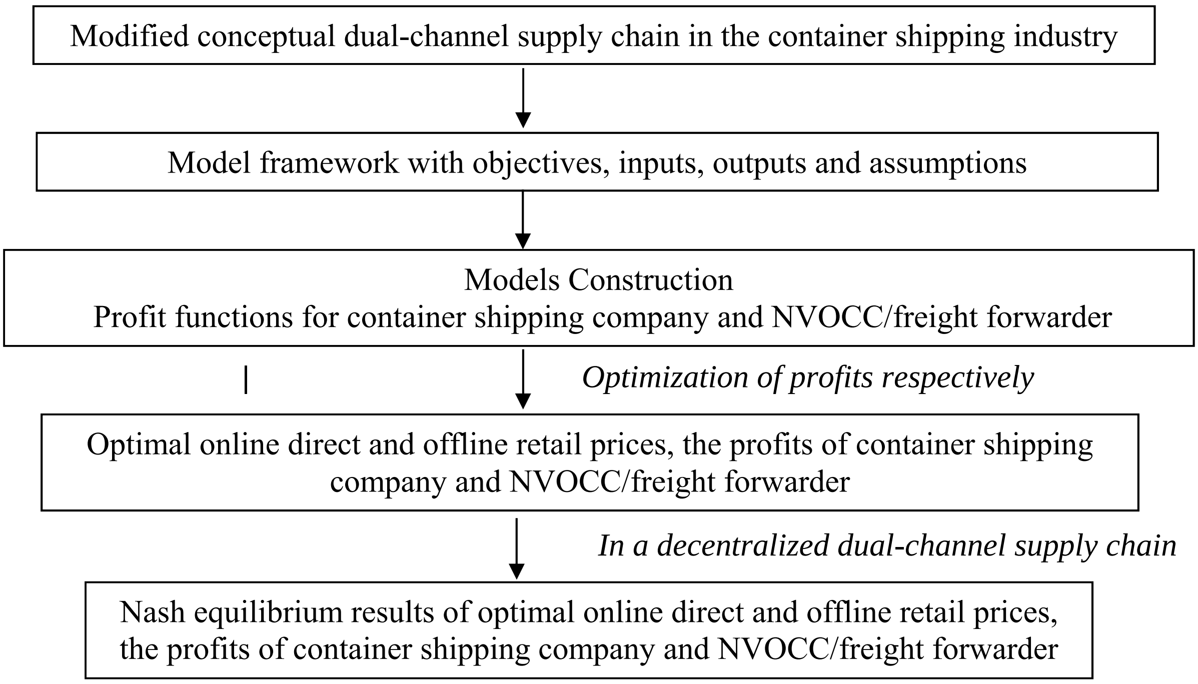


Figure 8. Steps of models' construction and optimization

3.1. The factors influencing the pricing strategy and profits in the dual-channel supply chain

The main factors that influence the pricing strategy and profits in the dual-channel supply chain differ from study to study as research on pricing strategy has shown (see Figure 9) (Kienzler & Kowalkowski, 2017). It is difficult to list all the factors that influence the pricing strategy and profits in the dual-channel supply chain; therefore, only the main factors that have been discussed in related articles.

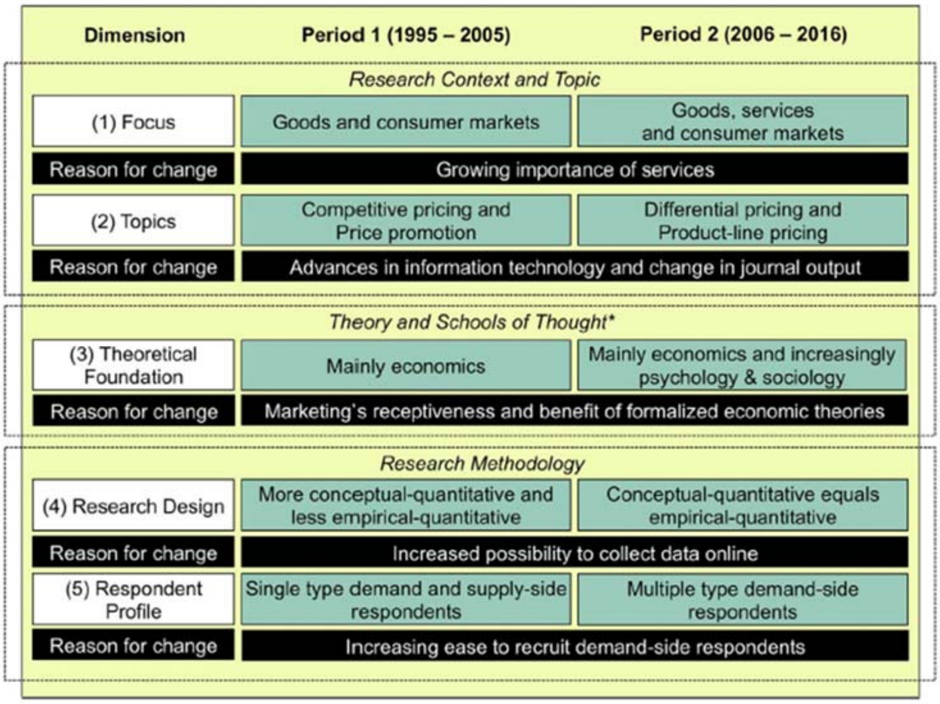


Figure 9. Key developments in pricing strategy research, 1995–2016.

Source: Kienzler & Kowalkowski (2017)

1. The risk preferences of stakeholders in dual-channel supply chain

The stakeholders in the supply chain have different risk appetites because they have different company backgrounds and their managers have different ideas. The stakeholders are normally categorized into two groups: risk seeking preferences and risk-averse preferences (Pennings & Smidts, 2000). The risk preferences of stakeholders play a vital role in the pricing strategy in the supply chain because the risk-averse stakeholders focus on stability while the risk-seeking stakeholders seek high return. Therefore, there are some articles studying the impact of stakeholders' different risk preferences on the pricing strategy in the supply chain (Q. Chen, Wang, Yu, & Tsai, 2018; Huo, Guo, & Cheng, 2019; J. Wang & Zhang, 2015). The articles, without consideration of the risk preferences, normally assumed all the stakeholders in the supply chain are risk neutral.

2. The manufacturer's cost

The profit of the manufacturer in the dual-channel supply chain has two sources: online direct channel and offline retail channel. The profits on different channels are both determined by the respective unit cost and unit-selling price.

The unit costs are different between online direct and offline retail channels. The first reason is that the online direct channel can save administration costs compared with the offline retail channel for manufacturers. The administration costs consist of wages for planning, booking, documentation, information and communication technology, and office labor management. The second reason is the online unit cost is dynamic. The investment and sales effort spent on online direct channels are changing in different stages of e-commerce evolvement. As discussed in the first section, manufacturers normally cannot benefit from the technology evolution and e-commerce immediately. The manufacturers who act as the pioneers at the e-commerce emergent stage inevitably evolve huge investments on the new technology, IT system, online website, human resources costs, know-how knowledge cost, the promotion on online platform and so forth.

On the other hand, the selling prices differ between online and offline channels. The offline unit-selling price offered by manufacturer to retailer is called the wholesale price. The online unit-selling price offered by manufacturer to consumers directly is named as the online direct price. The question of how to set the wholesale price, the online direct price and the offline retail price to maximize the profit of manufacturer in dual-channel supply chain attracts the attention of many researchers.

3. The retailer's cost

The profit of the retailer in the dual-channel supply chain comes solely from the offline retail channel. It is determined by the retailer's cost and offline retail price. The retailer's cost mainly includes the wholesale price offered by the manufacture, which is the discussed hot topic by many researchers. The way to set the wholesale price differs in various industry sectors with different market structures, pricing powers of the stakeholders in supply chain and so forth. The wholesale price can be directly determined by market, manufacturer, and retailer, or negotiated by two parties.

4. Market structure and the relationship between manufacture and retailer

There are four kinds of market structures: perfect competition, monopolistic competition, oligopoly and monopoly (Stackelberg, 2010). Each market structure has specific characteristics that influences the company decision-making and pricing strategy. Different market structure also leads to different relationships and order of actions between manufacturers and retailers, which is vital to the pricing strategy and profits in the dual-channel structure. As discussed in chapter 2, the game theory, which includes the manufacturer-lead Stackelberg model, retailer-lead Stackelberg model and Nash equilibrium model, has been widely applied to discuss the pricing strategy and profits in the dual-channel supply chain according to the different market structures and characteristics of industries.

5. Consumer demand

Consumer demand is an inevitable factor when discussing the pricing strategy and profits in the dual-channel supply chain. The assumption of consumers' demand differs in various studies. The consumers' demand is mostly assumed into stochastic demand or certain demand (Vahdani & Ahmadzadeh, 2019; L. Wang & Song, 2019). If the consumers' demand is stochastic, the study also has to verify the distribution of the demand, ie uniform distribution, normal distribution and Fisher Z distribution.

6. Consumer preference for online direct channel

It is inevitable to discuss consumer preference for the online direct channel in the dual-channel supply chain when studying the pricing strategy and profits. Consumer preference for the online direct channel is also dynamic in different stages of e-commerce evolvement. There are several articles studying the main determinants of consumer preference for the online direct channel. The online transaction cost, asset specificity and uncertainty of selling structure, time responsiveness, personalization, security, and reliability of online shopping platform are strongly related to consumer preference for the online direct channel from behavioral and economic perspectives (Devaraj, Fan, & Kohli, 2006). It has also been shown that trust, perceived ease of use, perceived usefulness and enjoyment are the influencing factors (Chiu, Chang, Cheng, & Fang, 2009). Based on these studies, the consumer preference for the online direct channel is considered as an influencing factor of pricing strategy and profits in the dual-channel supply chain (Mujkić, Qorri, & Kraslawski, 2018; Yoo & Lee, 2011; Yu, Shi, & Fang, 2019).

7. Consumers’ valuation of product

The willingness-to-pay price of consumers is determined by the consumers’ perfect valuation of the product utility and the their preference to the selling channel (Chiang, Chhajed, & Hess, 2003). It is the direct influencing factors for the pricing strategy and profits of manufacturer and retailer. The consumers will give up the purchasing if they have to pay more than their estimated valuation of the product.

8. Consumer purchase cost

The consumer purchase cost discussed here means the customers’ effort required for obtaining the tangible physical goods or intangible service (Cattani, Gilland, Heese, & Swaminathan, 2006). It consists of online purchase cost and offline purchase cost. It is put forward that the online channel only exists when it can reduce the customers’ transaction cost (Coughlan, Anderson, Stern, & El-Ansary, 2006). With reference to the transaction cost theory, the consumer’s purchase cost includes the search and information costs, bargaining costs and policing and enforcement costs (Williamson, 1993). On both the online direct and offline retail channels, the consumer purchase costs are controlled and perceived by consumers and third party and the details of consumer purchase cost are listed as follows (Rui, 2011): (1) Cost for buying the essential asset; (2) Learning cost in negotiation, especially on offline retail channel; (3) Searching cost that happened on both channels. (4) Time cost spent from the beginning to the end of transaction; (5) Risk cost due to the uncertainty and incomplete information during the transaction.

9. The characteristics of goods

The pricing strategy are different in a service supply chain because the manufacturer and retailer sell intangible services, not the physical commodities (. Wang, Wallace, Shen, & Choi, 2015). For example, there is no inventory cost for the manufacturer in the service supply chain, while the inventory management is a key topic in the supply chain of physical commodities. Even for all tangible physical commodities, the supply chain management is not the same. For example, perishable products have a special pricing strategy because the price is closely related to the freshness, and normally there is a recovery contract between manufacturer and retailer (Kouki, Babai, & Minner, 2018; Tao, Zhang, Peng, Shi, & Shi, 2019). For the emergency products, the main aim of the supply chain is to make sure that delivery is on time and reliable, not to maximize the profits or minimize the cost (Ben Othman, Zgaya, Dotoli, & Hammadi, 2017).

10. The characteristics of the supply chain

The pricing strategy and profits are very different in a decentralized and centralized dual-channel supply chain. In a decentralized supply chain, the stakeholders in the supply chain aim to maximize their own profits while in a centralized supply chain, the stakeholders aim to maximize the profits of the whole supply chain and make sure that their own profits are not worsened. Their actions are coordinated by various coordination contracts. In the centralized supply chain, there are many articles which show how manufacturers coordinate with retailers under the dual-channel. The relationship of a linear price and revenue sharing between two channels is established to coordinate the supply chain (Cai, 2010). A discount contract has been verified to be a useful tool to coordinate the supply chain too (Cai, Zhang, & Zhang, 2009). A coordinate agreement is established to achieve win-win result in a certain condition under which both suppliers and retailers prefer a dual-channel supply chain (Chen, Zhang, & Sun, 2012). The profit-sharing contract between supplier and buyer is suggested to coordinate the channel conflicts (Yan, 2008).

3.2. The modified conceptual dual-channel supply chain in the container shipping industry

The conceptual dual-channel supply chain in CSI contains one container shipping company and one NVOCC/Freight Forwarder. The manufacturer opens an online direct channel where the container slot can be sold directly to cargo owners as shown in Figure 10. However, the traditional conceptual dual-channel supply chain (see Figure 7) cannot be applied directly in CSI. Therefore, the modifications and explanations of the conceptual dual-channel supply chain in CSI are listed as follows:

a. The container shipping company is regarded as manufacturer, though the container shipping company does not manufacture any physical commodities. The inventory cost is not considered as modification in the models for pricing strategy and profits because the shipping service sold by container shipping companies cannot be stored.

b. An NVOCC/freight forwarder is regarded as a retailer. The inventory cost is also not considered for NVOCC/freight forwarders as modification for the models of pricing strategy and profits. Furthermore, the distance between the NVOCC/freight forwarder and the cargo owner is not considered when discussing the offline consumer purchase cost. The reason is that the shipping service is provided directly by container shipping companies, not by NVOCC/freight forwarders.

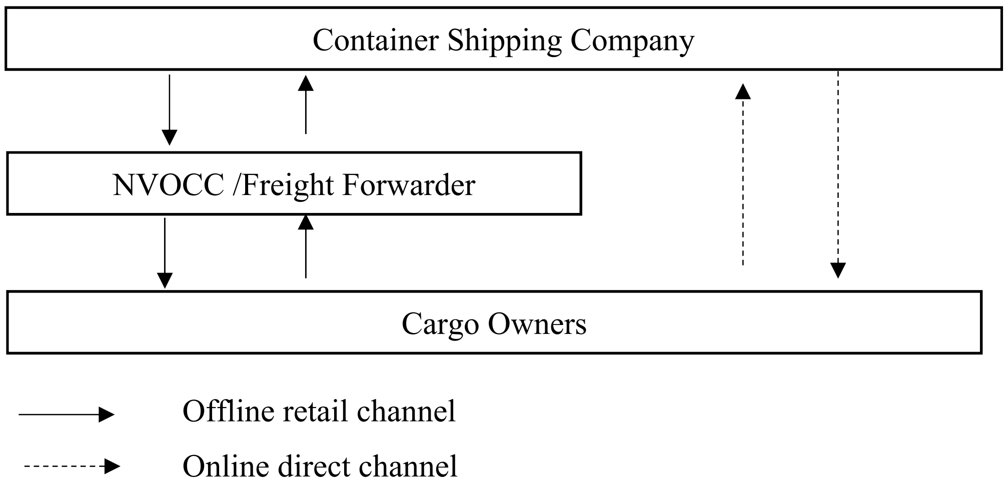


Figure 10. Conceptual dual-channel supply chain in CSI

3.3. Constructing models

After discussing the influencing factors and structuring the dual-channel supply chain in CSI, the model framework with objectives, inputs, outputs and assumptions are firstly constructed in this section. The models are established based on the framework, and the model construction has two steps. In the first step, the consumer utility functions for online direct and offline retail channels will be constructed based on the consumer purchase cost, consumer preference and choice theory. Then the demand functions for online direct and offline retail channels and profits functions for container shipping companies and NVOCC/freight forwarders are derived accordingly. The model construction steps are illustrated in Figure 11.

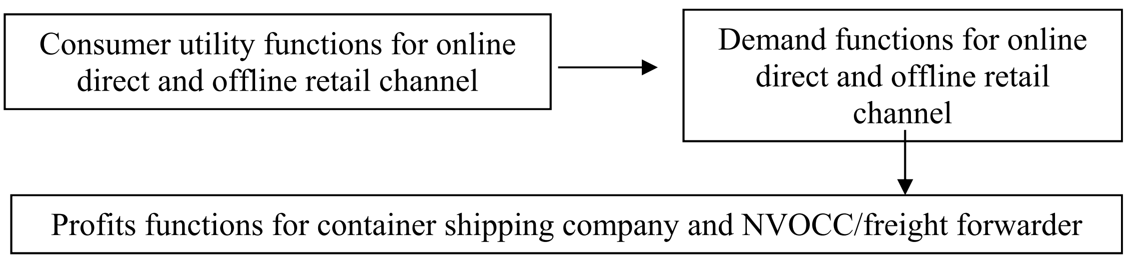


Figure 11. Steps of model construction

3.3.1. Model framework: objectives, inputs, outputs and assumptions

1. Model objective

This dissertation discusses the pricing strategy and profits of a container shipping company and an NVOCC/freight forwarder only in the decentralized dual-channel supply chain. In the decentralized supply chain, there is no cooperation between the container shipping company and the NVOCC/freight forwarder. The container shipping company and the NVOCC/freight forwarder take actions separately to maximize their own profits, and not the profits of the whole supply chain. Therefore, the objectives of models are maximizing the profits of the container shipping company and the NVOCC/freight forwarder.

2. Model inputs

In order to simplify the model's construction and optimization, there are some influencing factors discussed (see chapter 3.1), which are considered as inputs or independent variables of the models in this dissertation. The specific meanings of selected influencing factors or independent variables in CSI are explained as follows:

(1) Online and offline Consumer purchase costs in container shipping industry

Combined with the contents of consumer purchase cost in chapter 3.1, the cargo owners face various purchase costs on both online and offline channels. The search costs mean the cost of looking for a container shipping service with reasonable freight and sound service. The bargaining costs mean the costs of negotiation. The policing and enforcement costs include the time and money spent to ensure the cargo is transported safely and timely from port of loading to port of discharging. The consumer purchase cost on the offline retail channel and the online direct channel are denoted as b_r and b_d, respectively.

(2) Consumer preference for online direct channel in CSI

Though there are no related articles discussing the consumer preference for the online direct channel in the container liner industry, the general findings of consumer preference for online direct channel in chapter 3.2 are still applicable to CSI. When the cargo owners' preference for the online direct channel is increased through more efforts of the container shipping company, the pricing strategy and profits for the container shipping company and the NVOCC/freight forwarder must change accordingly. The consumer preference for the online direct channel in this dissertation is denoted as θ.

(3) Container shipping company's online and offline unit costs in CSI

The online and offline unit costs for the container shipping company are denoted as c_d and c_r, respectively. The container shippping company has different unit cost on online and offline channels. In addition to the reason that was put forward in chapter 3.1, the other reasons are as follows.

Similar to other commerical fields, costs and revenues in liner shipping companies are the determinants in the operational result. Due to the fierce competition within the sector, shipping companies have to be cost-effective to stay profitable. For instance, the high and low price of fuel can make the difference between loss and profit. Therefore, shipping companies seek to raise profits and reduce costs. There are six components of the cost in intercontinental container shipping, including: voyage costs, administration, maintenance/repair, container costs, port dues, and capital and insurance, as shown in Figure 12.

E-commerce in this sense is mostly related to administration costs, consisting of wages for planning, booking, documentation, information and communication technology, office and labor management. Compared to other cost categories, administration accounts for 20% of total shipping costs (Stopford, 2009). In order to reduce costs, administration is the element that should be focused on. The Internet based system, therefore, is an advanced investment to reduce costs. There are several reasons why documentation management in CSI is challenging. Firstly, there is a lack of standards. Every container shipping company has different booking systems and formats for their documents, especially Bill of Lading. A seamless coordination between parties becomes difficult due to the repeated typing and checking. Secondly, each container which is filled with a variety of commodities in compliance with different kinds of documents. It leads to the cumbersome dealing with an enormous quantity of documents. Thirdly, errors in documents are easy to spot. Documents that are exchanged between parties can meet the errors with the incomplete information or the conflict in the data together with the incidents with late or lost documents. Therefore, all these issues result in increasing administration costs between offline and online channels.

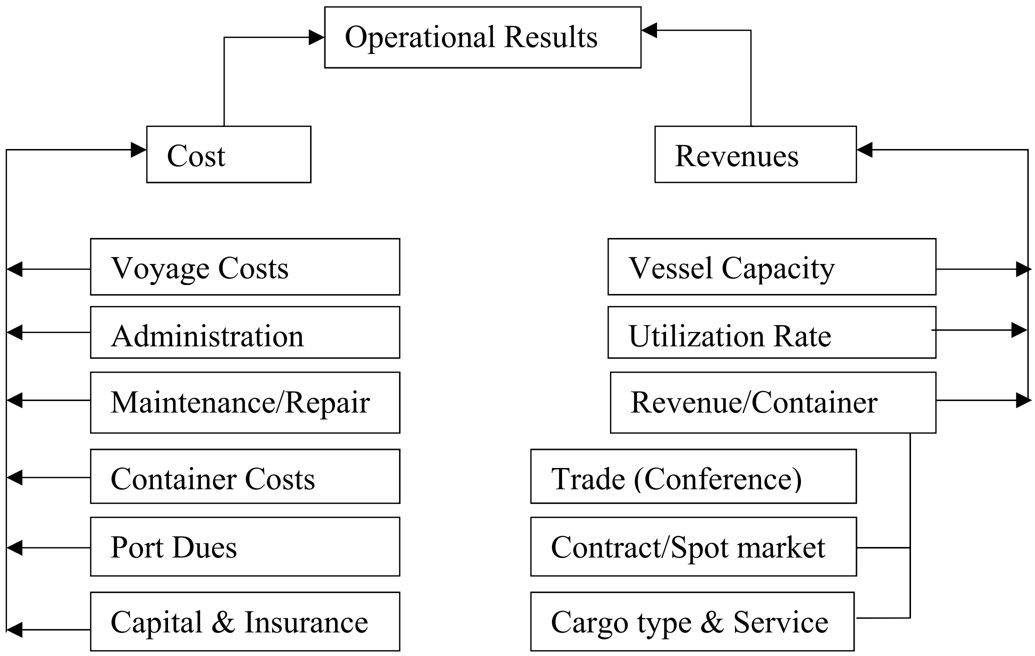


Figure 12. Ocean carrier cost-revenue breakdown.

Source: Stopford (2009)

(4) Wholesale price offered by container shipping company to NVOCC/freight forwarder

The wholesale price which is offered by the container shipping company to the NVOCC/freight forwarder decides the container shipping company's offline revenue directly. Moreover, the wholesale price offered by the container shipping company to the NVOCC/freight forwarder is the main cost of the NVOCC/freight forwarder and the only considered cost for NVOCC/freight forwarder in this dissertation. The wholesale price which is offered by the container shipping company to the NVOCC/freight forwarder is denoted as w.

(5) Consumers' valuation of container shipping service in CSI

As discussed in chapter 3.1, the consumers' valuation means cargo owners' perfect estimated valuation of the product, which should be substantially greater than the selling price. The consumers' valuation of shipping service in CSI is denoted as v.

3. Model outputs

This dissertation aims to find the Nash equilibrium of online direct and offline retail prices for the two players in the conceptual dual-channel supply chain in CSI, the container shipping company and the NVOCC/freight forwarder. All the following Nash equilibrium the results of models are put as the outputs. The Nash equilibrium results consist of optimal online direct price (denoted as p_r^N), optimal online direct price (denoted as p_d^N), profit of the container shipping company (denoted as π_m^N), profit of the NVOCC/freight forwarder (denoted as π_r^N), the market demand for online direct channel (denoted as Q_d^N) and the market demand for offline retail channel (denoted as Q_r^N).

4. Assumptions

In order to construct the models, assumptions are essential besides the objectives, inputs and outputs. The assumption for the dual-channel supply chain in CSI are concluded as follows.

(1) The dual-channel supply chain in CSI only considers one container shipping company and one NVOCC/freight forwarder.

(2) The wholesale price w offered by the container shipping company to the NVOCC/freight forwarder is assumed given and decided by the container freight market. The main reason is that the CSI is considered as an oligopoly market and the degree of oligopoly differs in different routes (Rau & Spinler, 2016; Sys, 2009). There are four different pricing models in the oligopoly market: Stackelberg model, price leadership model, Cournot Model and Bertrand Model. In the first model, the dominant container shipping companies can decide the capacity and freight rate, and other container shipping companies will follow. In the second model, one single container shipping company has a dominant market share (Jinhai, Siqin, & Ye, 2011). Both of the first two models are not applicable in CSI. The last two models are used to analyze the market with two container shipping companies, which cannot be applied in this dissertation because only one container shipping company is considered in the supply chain. Therefore, the wholesale price offered by the container shipping company to the retailer is considered as given and decided by the market.

(3) The dual-channel supply chain in CSI is a decentralized supply chain. There is no cooperation between the container shipping company and the NVOCC/freight forwarder. The container shipping company and the NVOCC/freight forwarder set online direct price and offline retail price at the same time and separately in order to maximize their own profits respectively. This is the current situation in reality.

(4) Assuming that the online direct price should be greater than the wholesale price offered by the container shipping company to the NVOCC/freight forwarder ($w < P_d$), otherwise the NVOCC/freight forwarder will purchase directly from online direct channel and the offline retail channel will not exist finally.

The notations of all the variables and the model framework in this dissertation are illustrated in Table 2 and Figure 13.

Table 2. Notations

b_r	Offline consumer purchase cost in container shipping industry	p_r^N	Nash equilibrium of optimal offline retail price
b_d	Online consumer purchase cost in container shipping industry	p_d^N	Nash equilibrium of optimal online direct price
θ	Consumer preference for online direct channel in container shipping industry	π_r^N	Nash equilibrium of profit of container shipping company
c_d	Container shipping company's onlilne unit cost	π_m^N	Nash equilibrium of profit of NVOCC/freight forwarder
c_r	Container shipping company's offline unit cost	Q_r^N	The market demand for offline retail channel
w	Wholesale price offered by container shipping company to NVOCC/freight forwarder	Q_d^N	The market demand for online direct channel
v	Consumers' valuation of container shipping service in container shipping industry		

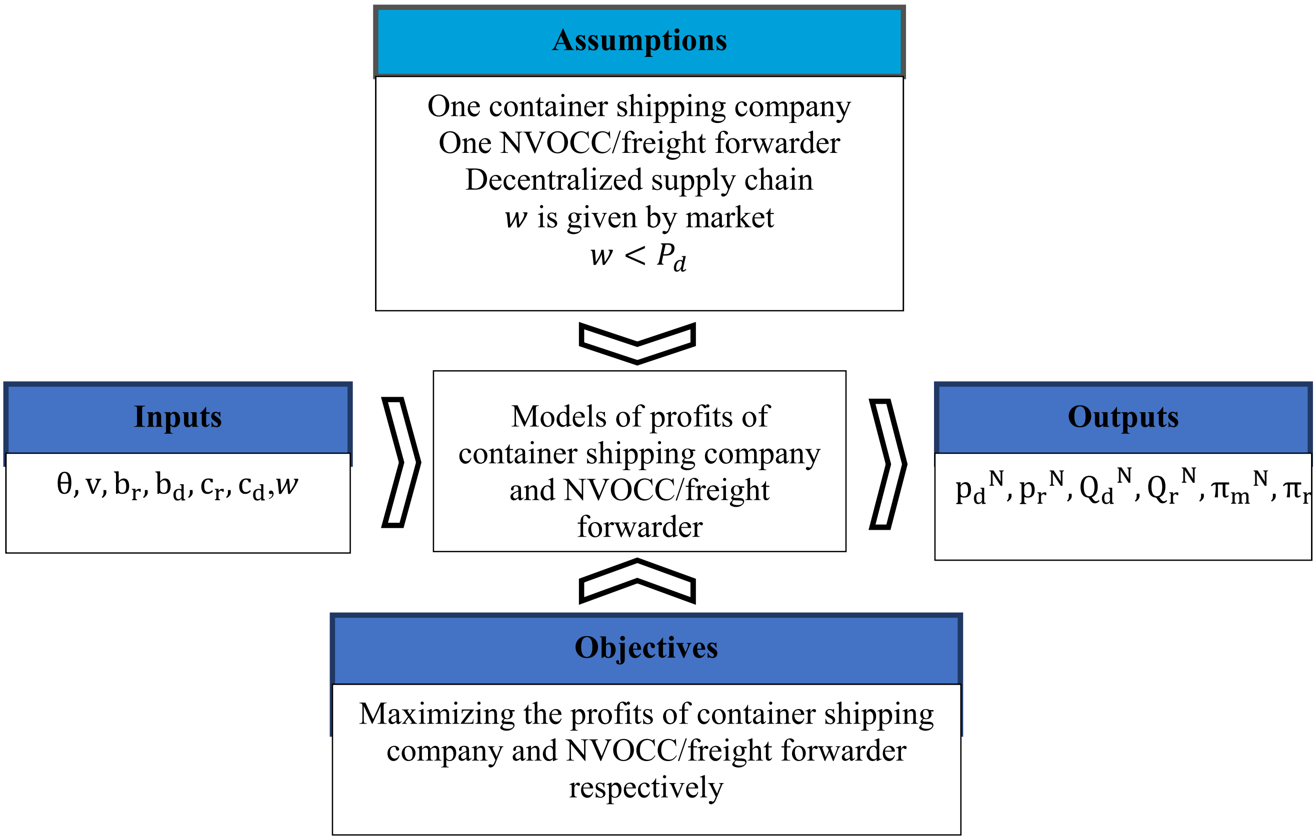


Figure 13. Model framework

3.3.2. The profit models for container shipping company and NVOCC/freight forwarder

Based on the model framework (see Figure 13) the consumer utility functions for online direct and offline retail channels will be discussed firstly based on the consumer purchase cost, consumer preference and choice theory. Then the profit models for container shipping companies and NVOCC/freight forwarders are derived accordingly.

1. Functions of online and offline consumer purchase cost

(1) Offline consumer purchase cost

With reference to the Hotelling Model, it is assumed that the NVOCC/freight forwarder is located in the origin whilst cargo owners are uniformly distributed in the interval [0, 1] on the X-axis. The uniform distribution density equals one ($N = 1$) as illustrated in Figure 14 (Hotelling, 1990). The offline consumer purchase cost differs when the cargo owners locate on different points on the X-axis.

Being different with the original model, the physical distance is replaced with the relation distance as the meaning of X-axis. In CSI, the NVOCC/freight forwarder acts as intermediator and the container shipping service is provided directly by container shipping companies (Wang et al., 2015). The offline consumer purchase cost in CSI is almost not related with the physical distance between the NVOCC/freight forwarder and cargo owners. In reality, the container shipment cannot be conducted only by seaborne transportation. The other supporting logistic activities are essential to support the container shipment, such as customs clearance, hinterland transportation, container loading and unloading. The NVOCC/freight forwarder not only sells the container shipping service, but also provides the other supporting logistic activities to cargo owners as additional service to improve the stability of the relationship with cargo owners. The relationship between the NVOCC/freight forwarder and the cargo owners correlates with the number of additional services that can be offered by the NVOCC/freight forwarder. Being closer to the NVOCC/freight forwarder in the model (see Figure 14), cargo owners enjoy higher stability trust with the NVOCC/freight forwarder and lower offline purchase cost. The reason is that the higher stability of the relationship can save cargo owners' search and information costs, bargaining costs and enforcement costs because of the lower uncertainty and risks in this transaction. What is more, the total quantity of cargo owners is assumed as one ($N = 1$) and it is assumed that each cargo owner buys one-unit container shipping service every time.

A linear cost function is applied to describe the offline purchase cost of cargo owners, and b_r is used as the cost coefficient. Therefore, the offline purchase cost for the cargo owners located at x on the X-axis is expressed as $b_r x$.

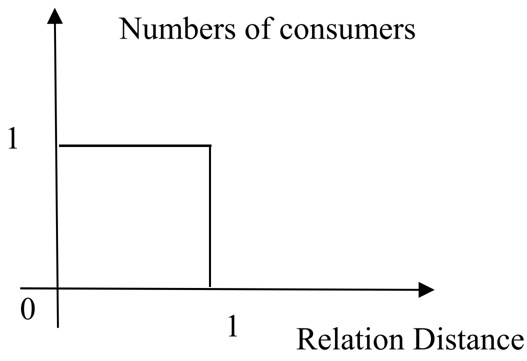


Figure 14. Consumer distribution.

Reproduced from "Stability in competition" by Hotelling, 1990.

(2) Online consumer purchase cost

It is assumed the cargo owners almost enjoy the same online consumer purchase cost. The reason is that the online consumer purchase cost is not influenced by the physical distance or relation distance between the cargo owners and container shipping company in the same region. Being different with the NVOCC/freight forwarder, the container shipping company only provides the seaborne transportation to cargo owners. The cargo owners can enjoy better price transparency on the online direct channel because of the homogeneous service. Being different with the offline consumer purchase cost, the online consumer purchase cost b_d is assumed as a constant.

2. Functions of online and offline consumer utility

The consumer preference for the offline retail channel equals to one in this dissertation, and the consumer preference for online direct channel θ is assumed to equal or less than one ($\theta \leq 1$) and regarded as the comparative acceptance of the online direct channel (Chuan-yong, 2009). The reason for assuming $\theta \leq 1$ is because cargo owners are expected to stay on the offline retail channel for a long time. The relationship between the NVOCC/freight forwarder and cargo owner is regarded to be stable in the current situation because the NVOCC/freight forwarder offers other supporting logistic services to cargo owners. Accordingly, the consumers' valuation of the unit container shipping service on the online direct channel is expressed as θv

(Chiang et al., 2003). Consumer utility means what the cargo owners gain from purchasing the container shipping service. Consumer utility in CSI equals consumers' valuation of unit container shipping service minus the costs they paid including the container freight and the purchase costs (Chiang et al., 2003). Therefore, the functions of the consumer's utility on the offline retail channel and online direct channel are expressed as equation 3.1 and 3.2 respectively.

$$u_r = v - p_r - b_r x \tag{3.1}$$

$$u_d = \theta v - p_d - b_d \tag{3.2}$$

The cargo owners make the decision of purchasing only when the utility is non-negative and select the selling channel with greater utility in the dual-channel supply chain in CSI.

3. The models of profits for container shipping company and NVOCC/freight forwarder

For the NVOCC/freight forwarder, the profit only comes from the offline retail channel. The unit of profit for the NVOCC/freight forwarder equals offline retail price p_r minus the wholesale price offered by the container shipping company w. Therefore, the total profit for the NVOCC/freight forwarder equals the unit of profit times the market demand for offline retail channel Q_r, as expressed in equation 3.3.

For the container shipping company, the profit comes from both online direct and offline retail channels. On the offline retail channel, the unit profit equals wholesale price w minus the offline unit cost c_r. Accordingly, the offline profit for the container shipping company equals the unit of profit times the market demand for offline retail channel Q_r; On the online direct channel, the unit profit equals the online direct price p_r minus the online unit cost c_d. Accordingly, the online profit for the container shipping company equals the unit profit times the market demand for the online direct channel Q_d. Therefore, the total profit of the container shipping company is the sum of online profit and offline profit, as shown in equation 3.4.

$$\pi_r = (p_r - w)Q_r \tag{3.3}$$

$$\pi_m = (w - c_r)Q_r + (p_d - c_d)Q_d \tag{3.4}$$

The total profits of the dual-channel supply chain are the sum of container shipping company's profit and NVOCC/freight forwarder's profit, as presented in equation 3.5.

$$\pi = \pi_m + \pi_r = (p_r - c_r)Q_r + (p_d - c_d)Q_d \quad (3.5)$$

The following optimization is conducted with the objective to maximize the profits of the container shipping company and the NVOCC/freight forwarder, respectively.

3.4. Derivation of optimal online direct and offline retail prices

Though the final outputs in this dissertation is to find the Nash equilibrium results of online direct and offline retail prices, the respective function of optimal online direct price and optimal offline retail prices have to be derived first. The reason is the Nash equilibrium results are the intersection points of the container shipping company's function of optimal online direct price and the NVOCC/freight forwarder's function of optimal offline retail price.

3.4.1. Optimal offline retail price NVOCC/freight forwarder

The NVOCC/freight forwarder's function of optimal offline retail price differs under different scenarios, as discussed in the following section. In the first scenario, the cargo owners only exist on the offline retail channel. In the second scenario, cargo owners exist on both online direct and offline retail channels.

1. Scenario 1: the cargo owners only exist on offline retail channel

When online consumer utility is negative ($p_d > \theta v - b_d$), the cargo owners will give up the online direct channel and choose the traditional offline channel. The demand for online direct channel equals zero in this scenario ($Q_d = 0$). On the offline retail channel, the cargo owners purchase only when they can obtain positive offline consumer utility ($u_r > 0$, or $p_r < v - b_r$).

According to equation 3.1 and Figure 14, the cargo owner who has the greatest offline purchase cost is located in the point of one (x=1). They suffer the greatest offline purchase cost b_r and enjoy the lowest offline consumer utility, which equals the offline consumers' valuation of unit container shipping service v minus the greatest offline purchase cost b_r $(v - b_r)$.

If the offline retail price p_r is greater than the wholesale price w and lower than the lowest offline consumer utility $(v - b_r)$, it means that all the cargo owners will purchase the contianer shipping service through the offline retail channel because all of them can get positive utility.

If the offline retail price p_r is greater than the lowest offline consumer utility $(v - b_r)$, only the cargo owners located between zero and $(v - b_r)/\, p_r$ (see Figure 14) can obtain positive utility.

Accordingly, the demand functions for the offline retail channel under previously mentioned two constrains are derived as equation 3.6.

$$Q_r = \begin{cases} 1, & w < p_r \le v - b_r \\ (v - p_r)/b_r, & v - b_r < p_r \le v \end{cases} \tag{3.6}$$

After applying the demand functions (equation 3.6) into the profit function (equation 3.3), the profit function of the NVOCC/freight forwarder in this scenario is derived as equation 3.7.

$$\pi_r = \begin{cases} p_r - w, & w < p_r \le v - b_r \\ (p_r - w)(v - p_r)/b_r, & v - b_r < p_r \le v \end{cases} \tag{3.7}$$

The objective of the NVOCC/freight forwarder is to maximize his own profit. Before finding the optimal offline retail price to maximize the profit of the NVOCC/freight forwarder, it has to be verified whether the maximum profit of the NVOCC/freight forwarder exists. The results of first-order and second-order partial derivative with respect to p_r are shown in equation 3.8 and 3.9 respectively.

$$\frac{\partial \pi_r}{\partial p_r} = \begin{cases} 1, & w < p_r \le v - b_r \\ \dfrac{-2p_r + v + w}{b_r}, & v - b_r < p_r \le v \end{cases} \tag{3.8}$$

$$\frac{\partial^2 \pi_r}{\partial {p_r}^2} = \begin{cases} 0, & w < p_r \le v - b_r \\ \dfrac{-2}{b_r}, & v - b_r < p_r \le v \end{cases} \tag{3.9}$$

As shown in equation 3.9, the second-order partial derivatives with respect to p_r are non-positive, which means the maximum profit of the NVOCC/freight forwarder denoted as π_r^* exists. The optimal offline retail price denoted as p_r^* can be obtained as equation 3.10 after ordering the first-order partial derivative with respect to p_r to zero ($\frac{\partial \pi_r}{\partial p_r}$=0).

$${p_r}^* = \begin{cases} v - b_r, & w \le v - 2b_r \\ \dfrac{v + w}{2}, & v - 2b_r < w \le v \end{cases} \tag{3.10}$$

2. Scenario 2: cargo owners exist on both offline and online direct channels

When online consumer utility is non-negative ($p_d \le \theta v - b_d$), the cargo owners will not give up the online direct channel and choose the selling channel with greater consumer utility between online and offline channels. For example, cargo owners will select the offline retail channel when they can obtain greater offline consumer utility than the online direct channel

($u_r = v - p_r - b_r x > u_d = \theta v - p_d - b_d$ or $x < [(1-\theta)v + p_d + b_d - p_r]/b_r$).

If $[(1-\theta)v + p_d + b_d - p_r]/b_r$ is greater than one, X is definetily less than $[(1-\theta)v + p_d + b_d - p_r]/b_r$, which means all the cargo owners select the offline retail channel and demand for the offline retail channel Q_r equals one.

If $[(1-\theta)v + p_d + b_d - p_r]/b_r$ is less than one, only the cargo owners located between zero and $[(1-\theta)v + p_d + b_d - p_r]/b_r$ (see Figure 14) can obtain positive utility.

Accordingly, the demand functions for the offline retail channel under previously mentioned two constrains are derived as equation 3.11.

$$Q_r = \begin{cases} 1, & w < p_r \le (1\text{-}\theta)v + b_d - b_r + p_d \\ [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r, & (1\text{-}\theta)v + b_d - b_r + p_d < p_r \le v \end{cases} \tag{3.11}$$

After applying the demand functions (equation 3.11) into the profit function (equation 3.3), the profit function of the NVOCC/freight forwarder in this scenario is derived as equation 3.12.

$$\pi_r = \begin{cases} p_r - w, & w < p_r \leq (1\text{-}\theta)v + b_d - b_r + p_d \\ (p_r - w)[(1\text{-}\theta)v + b_d - p_r + p_d]/b_r, & (1\text{-}\theta)v + b_d - b_r + p_d < p_r \leq v \end{cases} \quad (3.12)$$

Being similar with scenario 1, the results of first-order and second-order partial derivative with respect to p_r are shown in equation 3.13 and 3.14 respectively.

$$\frac{\partial \pi_r}{\partial p_r} = \begin{cases} 1, & w < p_r \leq (1\text{-}\theta)v + b_d - b_r + p_d \\ \dfrac{v + w - v\theta + b_d + p_d - 2p_r}{b_r}, & (1\text{-}\theta)v + b_d - b_r + p_d < p_r \leq v \end{cases} \quad (3.13)$$

$$\frac{\partial^2 \pi_r}{\partial {p_r}^2} = \begin{cases} 0, & w < p_r \leq (1\text{-}\theta)v + b_d - b_r + p_d \\ \dfrac{-2}{b_r}, & (1\text{-}\theta)v + b_d - b_r + p_d < p_r \leq v \end{cases} \quad (3.14)$$

As presented in equation 3.14, the second-order partial derivatives with respect to p_r are non-positive, which means the maximum profit of the NVOCC/freight forwarder exists. The optimal offline retail price can be obtained as equation 3.15 after ordering the first-order partial derivative with respect to p_r to zero ($\frac{\partial \pi_r}{\partial p_r}$=0).

$$p_r^* = \begin{cases} (1-\theta)v + b_d - b_r + p_d, & w \leq v - v\theta + b_d - 2b_r + p_d \\ \dfrac{1}{2}(v + w - v\theta + b_d + p_d), & v - v\theta + b_d - 2b_r + p_d < w \leq v \end{cases} \quad (3.15)$$

3.4.2. Optimal online direct price for container shipping company

Being similar with the NVOCC/freight forwarder, the container shipping company's function of optimal online direct price also differs under different scenarios as discussed below. In the first scenario, cargo owners only exist on the offline retail channel. In the second scenario, cargo owners exist on both online direct and offline retail channels. In the third scenario, cargo owners exist only on the online direct channel.

1. Scenario 1: the cargo owners only exist on online direct channel

The cargo owners will choose the online direct channel only when the online consumer utility is greater than the maximum offline consumer utility. The maximum offline consumer utility happens when the relation distance X (see Figure 14) equals zero (X=0), and it is expressed as $u_r = v - p_r$. Therefore, the condition that cargo owners only select the online direct channel can be expressed as $u_r = v - p_r < u_d = \theta v - p_d - b_d$ or $p_d \leq p_r - (1\text{-}\theta)v - b_d$. In this scenario, the demand for the online direct channel equals one, and the demand for the offline retail channel equals zero, as expressed in equation 3.16 and 3.17.

$$Q_r = 0, \quad p_d \leq p_r - (1\text{-}\theta)v - b_d \tag{3.16}$$

$$Q_d = 1, \quad p_d \leq p_r - (1\text{-}\theta)v - b_d \tag{3.17}$$

After applying the demand functions (equation 3.6 and 3.7) into the profit function (equation 3.4), the profit function of the container shipping company, denoted as π_m, is derived as equation 3.18. The profit function for the container shipping company increases with the online direct price in this scenario.

$$\pi_m = p_d - c_d, \quad p_d \leq p_r - (1\text{-}\theta)v - b_d \tag{3.18}$$

2. Scenario 2: the cargo owners exist on both online direct and offline retail channels

As discussed in scenario 1, the maximum offline consumer utility is expressed as $u_r = v - p_r$. Similarly, the minimum offline consumer utility occurs when the relation distance X (see Figure 14) equals 1 (X=1), and it is expressed as $u_r = v - p_r - b_r$. When the online consumer utility exists between the maximum offline consumer utility and minimum offline consumer utility, cargo owners exist on both online direct and offline retail channels. This condition can be expressed as $v - p_r - b_r < u_d = \theta v - p_d - b_d < v - p_r$ or $p_r - (1\text{-}\theta)v - b_d < p_d < p_r - (1\text{-}\theta)v - b_d + b_r$.

When deriving the online and offline demand functions, there are two situations that needs to be considered, as outlined below.

(1) The minimum offline consumer utility is greater than zero

The situation that minimum offline consumer utility is greater than zero is expressed as $u_r = v - p_r - b_r > 0$ or $p_r \le v - b_r$. In this situation, all the cargo owners can obtain positive utility through the offline retail channel.

When facing online direct and offline retail channels, cargo owners will select the selling channel with higher consumer utility. The offline and online consumer utilities are same when $v - p_r - b_r x = \theta v - p_d - b_d$ or $x = [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r$ is satisfied, which means the cargo owners located at the point $x = [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r$ have same online and offline comsumers' untilites. For the cargo owners located between zero and $x = [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r$, the offline consumer utility is greater than online consumer utility, and they will select the offline retail channel. Simillarly, for the cargo owners located between $x = [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r$ and one, the online consumer utility is greater than offline consumer utility, and they will select the online direct channel. Accordingly, the demand functions for offline and online direct channels are derived as equation 3.19 and 3.20 when conditions $p_r - (1\text{-}\theta)v - b_d < p_d < p_r - (1\text{-}\theta)v - b_d + b_r$ and $p_r \le v - b_r$ are both satisfied.

$$Q_r = [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r \tag{3.19}$$

$$Q_d = 1\text{-}[(1\text{-}\theta)v + b_d - p_r + p_d]/b_r \tag{3.20}$$

After applying the demand functions (equation 3.19 and 3.20) into the profit function (equation 3.4), the profit function for the container shipping company in this scenario is derived as equation 3.21.

$$\pi_m = (w - c_r)Q_r + (p_d - c_d)(1 - Q_r) = (w - c_r)[(1\text{-}\theta)v + b_d - p_r + p_d]/b_r + (p_d - c_d)(1 - [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r) \tag{3.21}$$

The objective of the container shipping company is to maximize his own profit. Similarly, it has to be verified whether the maximum profit of the container shipping company exists first. The results of first-order and second-order partial derivative with respect to p_d are shown in equation 3.22 and 3.23 respectively.

$$\frac{\partial \pi_r}{\partial p_d} = \frac{-v + w + v\theta - b_d + b_r + c_d - c_r - 2p_d + p_r}{b_r} \tag{3.22}$$

$$\frac{\partial^2 \pi_r}{\partial {p_d}^2} = \frac{-2}{b_r} \tag{3.23}$$

As presented in equation 3.19, the second-order partial derivatives with respect to p_d are non-positive, which means the the maximum profit of the container shipping company exists. The optimal online direct price, denoted as p_d^* can be obtained as equation 3.24 after ordering the first-order partial derivative with respect to p_d to zero ($\frac{\partial \pi_r}{\partial p_d}$=0).

$$p_d^* = \frac{1}{2}\left(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r\right) \tag{3.24}$$

(2) The minimum offline consumer utility is lower than zero

The situation that minimum offline consumer utility is lower than zero is expressed as $u_r = v - p_r - b_r < 0$ or $p_r > v - b_r$. In this situation, the condition for the existence of online direct channel is the cargo owners can get positive online consumer utility, and the condition can be expressed as $0 \le u_d = \theta v - p_d - b_d$ or $p_d \le \theta v - b_d$.

When the conditions that $p_r - (1\text{-}\theta)v - b_d < p_d < p_r - (1\text{-}\theta)v - b_d + b_r$, $p_r > v - b_r$ and $p_d \le \theta v - b_d$ are all satisfied, the demand function for offline retail channel, the demand function for online direct channel and the function of optimal online direct price are same with the results in first situation, and they are derived as same as equations 3.19, 3.20 and 3.24 respectively.

$$Q_r = [(1\text{-}\theta)v + b_d - p_r + p_d]/b_r \tag{3.19}$$

$$Q_d = 1\text{-}[(1\text{-}\theta)v + b_d - p_r + p_d]/b_r \tag{3.20}$$

$$p_d^* = \frac{1}{2}\left(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r\right) \tag{3.24}$$

3. Scenario 3: the cargo owners exist only on offline retail channels

The cargo owners will choose the offline retail channel only when the minimum offline consumer utility is greater than online consumer utility. The minimum offline consumer utility occurs when the relation distance X (see Figure 14) equals one (X =0), and it is expressed as $u_r = v - p_r - b_r$. Therefore, the condition that cargo owners only select the offline retail channel can be expressed as $u_r = v - p_r - b_r > u_d = \theta v - p_d - b_d$ or $p_d > p_r - (1\text{-}\theta)v - b_d + b_r$. In this scenario, the demand for online direct channel equals zero as expressed in equation 3.25, and the demand for offline retail channel equals one.

$$Q_d = 0 \tag{3.25}$$

After applying the demand function (equation 3.25) into the profit function (equation 3.4), the profit function for the container shipping company in this scenario is derived as equation 3.26. The profit function for the container shipping company is not related with the offline retail price in this scenario.

$$\pi_m = w - c_r \tag{3.26}$$

4. Summary

After discussing the three different scenarios in this section, the functions of profit for the container shipping company are derived in correspondent intervals. Then where the maximum profit of the container shipping company is in the whole interval has to be discussed.

The function of profit for the container shipping company is continuous in the first and second scenarios. In the first scenario, the profit of the container shipping company π_m is an incremental function of online direct price p_d (equation 3.18). In the second scenario, the profit of container shipping company π_m is a Convex function of online direct price p_d (equation 3.21). In the third scenario, the profit of container shipping company π_m has no relation with online direct price p_d. In addition, the profit of the container shipping company in the third scenario is lower than the profit of the container shipping company when $p_d = p_r - (1\text{-}\theta)v - b_d + b_r$ in the second scenario (equation 3.26). In conclusion, the maximum profit of container shipping company exists at the ends of or inside the interval in the second scenario:

$p_r - (1\text{-}\theta)v - b_d < p_d < p_r - (1\text{-}\theta)v - b_d + b_r$.

By comparing the values of p_d^*, $p_r - (1\text{-}\theta)v - b_d$ and $p_r - (1\text{-}\theta)v - b_d + b_r$, the optimal online price for the container shipping company is derived as follows.

(1) When $b_d < -w + v\theta - b_r - c_d + c_r$ is satisfied, p_d^* is expressed as equation 3.27.

$$p_d^* = \begin{cases} w, & p_r < v + w - v\theta + b_d - b_r - c_d + c_r \\ \frac{1}{2}\left(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r\right), & v + w - v\theta + b_d - b_r - c_d + c_r \le p_r < v + w - v\theta + b_d + b_r + c_d - c_r \\ p_r - (1-\theta)v - b_d, & v + w - v\theta + b_d + b_r + c_d - c_r \le p_r < v \end{cases}$$

(3.27)

(2) When $b_d \ge -w + v\theta - b_r - c_d + c_r$ is satisfied, p_d^* is expressed as equation 3.28.

$$p_d^* = \begin{cases} w, & p_r < v + w - v\theta + b_d - b_r - c_d + c_r \\ \frac{1}{2}\left(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r\right), & v + w - v\theta + b_d - b_r - c_d + c_r \le p_r < v - w + \theta v - b_d - b_r - c_d + c_r \\ \theta v - b_d, & v - w + \theta v - b_d - b_r - c_d + c_r \le p_r < v \end{cases}$$

(3.28)

3.5. Nash equilibrium results of online direct and offline retail prices, demands and profits

The Nash equilibrium results mean the stable state that both the container shipping company and the NVOCC/freight forwarder cannot gain more benefits if the other parties have no change their pricing strategy and actions (Osborne, 2004). In order to find Nash equilibrium results of online direct and offline retail prices, it is assumed that the container shipping company and the NVOCC/freight forwarder have full information of each other's strategies, and they adopt the optimal pricing strategy for themselves to maximize their own profits based on the full information. Moreover, it is a static one-stage game between the container shipping company and the NVOCC/freight forwarder because they set the online direct and offline retail price separately at the same time.

It is easy to find that the optimal offline retail price for the NVOCC/freight forwarder is a function of the container shipping company's online direct price, as shown in equation 3.10 and 3.15. Similarly, the optimal online direct price for the container shipping company is a function of the NVOCC/freight forwarders offline retail price, as shown in equation 3.27 and 3.28. Therefore, the intersection points of the container shipping company's function of optimal online direct price and the NVOCC/freight forwarder's function of optimal offline retail price are the Nash equilibrium results between the container shipping company and the NVOCC/freight forwarder. The Nash equilibrium results are a strategy combination consisting of the respective best strategy of the container shipping company and the NVOCC/freight forwarder.

Similar to chapter 3.4, two scenarios are studied here. The first scenario is cargo owners only exist on the offline retail channel. The second scenario is cargo owners exist on both online direct and offline retail channels.

3.5.1. Scenario 1: cargo owners only exist on offline retail channel

Cargo owners will give up the online direct channel when they cannot obtain positive online consumer utility ($u_d = \theta v - b_d - p_d < 0$). In this situation, there is no need to analyze the optimal online direct price because the demand for the online direct channel is zero. Therefore, only the NVOCC/freight forwarder has to calculate the optimal offline retail price. In this scenario, the NVOCC/freight forwarder's optimal selling price and demand for offline retail channel, denoted as p_r^{off} and Q_r^{off}, are listed equation 3.29 and 3.30 based on the discussion in chapter 3.4.1.

$$p_r^{off} = \begin{cases} v - b_r, & w \le v - 2b_r \\ \dfrac{v+w}{2}, & v - 2b_r < w \le v \end{cases} \tag{3.29}$$

$$Q_r^{off} = \begin{cases} 1, & w \le v - 2b_r \\ \dfrac{v-w}{2b_r}, & v - 2b_r < w \le v \end{cases} \tag{3.30}$$

After applying the demand functions (equation 3.30) into the profit functions (equation 3.3 and 3.4), the profit functions for the NVOCC/freight forwarder and the container shipping company in this scenario are derived as equation 3.31 and 3.32 respectively.

$$\pi_r = \begin{cases} v - w - b_r, & w \le v - 2b_r \\ \dfrac{(v-w)^2}{4b_r}, & v - 2b_r < w \le v \end{cases} \tag{3.31}$$

$$\pi_m = \begin{cases} w - c_r, & w \le v - 2b_r \\ \dfrac{(v-w)(w-c_r)}{2b_r}, & v - 2b_r < w \le v \end{cases} \tag{3.30}$$

3.5.2. Scenario 2: cargo owners do not only exist on offline retail channel

In the scenario that cargo owners not only exist on the offline retail channel, in chapter 3.4.1, the equations of optimal offline retail price for the NVOCC/freight forwarder differ under different conditions (equation 3.15), so do the equations of optimal online direct price for the container shipping company (equation 3.24). After combining the constrains of optimal offline and online direct prices, the Nash equilibrium results are finally discussed under the following six constrains.

1. Constrains: $w \le \theta v - b_d < w - (1-\theta)v + 2b_r - b_d$, $v - v\theta + b_d - b_r - c_d + c_r > 0$

When $w \le \theta v - b_d < w - (1-\theta)v + 2b_r - b_d$ and $v - v\theta + b_d - b_r - c_d + c_r > 0$ are satisfied, the optimal offline retail price for NVOCC/freight forwarder p_d^* is derioved as equation 3.29. The optimal online direct price for the container shipping company p_d^* is shown in equation 3.28.

$$p_r^* = \begin{cases} \frac{1}{2}(v + w - v\theta + b_d + p_d), & p_d < v\theta - b_d \\ \frac{v+w}{2}, & p_d \geq v\theta - b_d \end{cases} \tag{3.29}$$

$$p_d^* = \begin{cases} w, & p_r < v + w - v\theta + b_d - b_r - c_d + c_r \\ \frac{1}{2}(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r), & v + w - v\theta + b_d - b_r - c_d + c_r \leq p_r < v - w + \theta v - b_d - b_r - c_d + c_r \\ \theta v - b_d, & v - w + \theta v - b_d - b_r - c_d + c_r \leq p_r < v \end{cases}$$

(3.28)

After finding the intersections of equation 3.28 and 3.29, the Nash equilibrium results of online direct and offline retail price are derived as follows.

(1) When $b_d + b_r + c_d - c_r + (1-\theta)v > \frac{3}{2}(v - w)$ is satisfied, the Nash equilibrium of online direct price p_d^N and offline retail price p_r^N are presented as equation 3.30 and 3.31 respectively.

$$p_d^N = w + \frac{1}{3}(-b_d + 2b_r + 2c_d - 2c_r - (1-\theta)v) \tag{3.30}$$

$$p_r^N = w + \frac{1}{3}(b_d + b_r + c_d - c_r + (1-\theta)v) \tag{3.31}$$

(2) When $b_d + b_r + c_d - c_r + (1-\theta)v < \frac{3}{2}(v - w)$ is satisfied, p_d^N and p_r^N are expressed as equation 3.32 and 3.33 respectively.

$$p_d^N = \theta v - b_d \tag{3.32}$$

$$p_r^N = \frac{v + w}{2} \tag{3.33}$$

2. Constrains: $w \le \theta v - b_d < w-(1-\theta)v+2b_r - b_d$, $v - v\theta + b_d - b_r - c_d + c_r < 0$

When $w \le \theta v - b_d < w-(1-\theta)v+2b_r - b_d$ and $v - v\theta + b_d - b_r - c_d + c_r < 0$ are satisfied, the optimal offline retail price for the NVOCC/freight forwarder p_d^* is derived as same as equation 3.29. The optimal online direct price for the container shipping company p_d^* is shown in equation 3.27.

$$p_r^* = \begin{cases} \frac{1}{2}\left(v + w - v\theta + b_d + p_d\right), & p_d < v\theta - b_d \\ \frac{v+w}{2}, & p_d \ge v\theta - b_d \end{cases} \tag{3.29}$$

When $b_d < -w + v\theta - b_r - c_d + c_r$ is satisfied, p_d^* is listed as follows.

$$p_d^* = \begin{cases} w, & p_r < v + w - v\theta + b_d - b_r - c_d + c_r \\ \frac{1}{2}\left(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r\right), & v + w - v\theta + b_d - b_r - c_d + c_r \le p_r < v + w - v\theta + b_d + b_r + c_d - c_r \\ p_r - (1-\theta)v - b_d, & v + w - v\theta + b_d + b_r + c_d - c_r \le p_r < v \end{cases} \tag{3.27}$$

After finding the intersections of equation 3.29 and 3.27, the Nash equilibrium results of online direct and offline retail price are derived as follows.

(1) When $b_d + b_r + c_d - c_r + (1-\theta)v > \frac{3}{2}(v - w)$ is satisfied, p_d^N and p_r^N are derived as same as equation 3.30 and 3.31.

$$p_d^N = w + \frac{1}{3}\left(-b_d + 2b_r + 2c_d - 2c_r - (1-\theta)v\right) \tag{3.30}$$

$$p_r^N = w + \frac{1}{3}\left(b_d + b_r + c_d - c_r + (1-\theta)v\right) \tag{3.31}$$

(2) When $b_d + b_r + c_d - c_r + (1-\theta)v < \frac{3}{2}(v-w)$ is satisfied, p_d^N and p_r^N are derived as same as equation 3.32 and 3.33

$$p_d^N = \theta v - b_d \tag{3.32}$$

$$p_r^N = \frac{v+w}{2} \tag{3.33}$$

3. Constrains: $w < w-(1-\theta)v+2b_r - b_d < \theta v - b_d$, $v - v\theta + b_d - b_r - c_d + c_r > 0$

When $w < w-(1-\theta)v+2b_r - b_d < \theta v - b_d$ and $v - v\theta + b_d - b_r - c_d + c_r > 0$ are satisfied, the optimal offline retail price for the NVOCC/freight forwarder p_d^* is derived as equation 3.34. The optimal online direct price for the container shipping company p_d^* is shown in equation 3.28.

$$p_r^* = \begin{cases} (1-\theta)v + b_d - b_r + p_d, & w-(1-\theta)v+2b_r - b_d > p_d \\ \frac{1}{2}(v + w - v\theta + b_d + p_d), & w-(1-\theta)v+2b_r - b_d < p_d < \theta v - b_d \\ v - b_r, & p_d \geq v\theta - b_d \end{cases}$$

(3.34)

$$p_d^* = \begin{cases} w, & p_r < v+w-v\theta+b_d-b_r-c_d+c_r \\ \frac{1}{2}(-v+w+v\theta-b_d+b_r+c_d-c_r+p_r), & v+w-v\theta+b_d-b_r-c_d+c_r \leq p_r < v-w+\theta v-b_d-b_r-c_d+c_r \\ \theta v - b_d, & v-w+\theta v-b_d-b_r-c_d+c_r \leq p_r < v \end{cases}$$

(3.28)

After finding the intersections of equation 3.34 and 3.28, the Nash equilibrium results of online direct and offline retail price are derived as equation 3.35 and 3.36 respectively.

$$p_d^N = \mathrm{w} \tag{3.35}$$

$$p_r^{\ N} = (1-\theta)v + b_d - b_r + w \qquad (3.36)$$

4. Constrains: $w < w-(1-\theta)v+2b_r - b_d < \theta v - b_d$, $v - v\theta + b_d - b_r - c_d + c_r < 0$

When $w < w-(1-\theta)v+2b_r - b_d < \theta v - b_d$ and $v - v\theta + b_d - b_r - c_d + c_r < 0$ are satisfied, the optimal offline retail price for the NVOCC/freight forwarder p_d^* is derived as same as equation 3.34. The optimal online direct price for the container shipping company p_d^* is shown in equation 3.27.

$$p_r^* = \begin{cases} (1-\theta)v + b_d - b_r + p_d, & w-(1-\theta)v+2b_r - b_d > p_d \\ \frac{1}{2}(v + w - v\theta + b_d + p_d), & w-(1-\theta)v+2b_r - b_d < p_d < \theta v - b_d \\ v - b_r, & p_d \geq v\theta - b_d \end{cases} \qquad (3.34)$$

$$p_d^* = \begin{cases} w, & p_r < v + w - v\theta + b_d - b_r - c_d + c_r \\ \frac{1}{2}(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r), & v + w - v\theta + b_d - b_r - c_d + c_r \leq p_r < v + w - v\theta + b_d + b_r + c_d - c_r \\ p_r - (1-\theta)v - b_d, & v + w - v\theta + b_d + b_r + c_d - c_r \leq p_r < v \end{cases}$$

(3.27)

After finding the intersections of equation 3.34 and 3.27, the Nash equilibrium results of online direct and offline retail price are derived as same as equation 3.35 and 3.36 respectively.

$$p_d^{\ N} = \mathrm{w} \qquad (3.35)$$

$$p_r^{\ N} = (1-\theta)v + b_d - b_r + w \qquad (3.36)$$

5. Constrains: $w-(1-\theta)v+2b_r - b_d < w < \theta v - b_d$, $v - v\theta + b_d - b_r - c_d + c_r > 0$

When $w-(1-\theta)v+2b_r - b_d < w < \theta v - b_d$ and $v - v\theta + b_d - b_r - c_d + c_r > 0$ are satisfied, the optimal offline retail price for the NVOCC/freight forwarder p_d^* is derived as same as equation 3.34. The optimal online direct price for the container shipping company p_d^* is shown in equation 3.28.

$$p_r^* = \begin{cases} (1-\theta)v + b_d - b_r + p_d, & w-(1-\theta)v+2b_r - b_d > p_d \\ \frac{1}{2}(v + w - v\theta + b_d + p_d), & w-(1-\theta)v+2b_r - b_d < p_d < \theta v - b_d \\ v - b_r, & p_d \geq v\theta - b_d \end{cases} \quad (3.34)$$

$$p_d^* = \begin{cases} w, & p_r < v+w-v\theta+b_d-b_r-c_d+c_r \\ \frac{1}{2}(-v+w+v\theta-b_d+b_r+c_d-c_r+p_r), & v+w-v\theta+b_d-b_r-c_d+c_r \leq p_r < v-w+\theta v-b_d-b_r-c_d+c_r \\ \theta v-b_d, & v-w+\theta v-b_d-b_r-c_d+c_r \leq p_r < v \end{cases}$$

(3.28)

After finding the intersections of equation 3.34 and 3.28, the Nash equilibrium results of online direct and offline retail price are derived as same as equation 3.35 and 3.36 respectively.

$$p_d^N = w \quad (3.35)$$

$$p_r^N = (1-\theta)v + b_d - b_r + w \quad (3.36$$

6. Constrains: $w-(1-\theta)v+2b_r-b_d < w < \theta v-b_d$, $v-v\theta+b_d-b_r-c_d+c_r<0$

When $w-(1-\theta)v+2b_r-b_d < w < \theta v-b_d$ are $v-v\theta+b_d-b_r-c_d+c_r<0$ satisfied, the optimal offline retail price for the NVOCC/freight forwarder p_d^* is derived as same as equation 3.34. The optimal online direct price for the container shipping company p_d^* is shown in equation 3.28.

$$p_r^* = \begin{cases} (1-\theta)v + b_d - b_r + p_d, & w-(1-\theta)v+2b_r - b_d > p_d \\ \frac{1}{2}(v + w - v\theta + b_d + p_d), & w-(1-\theta)v+2b_r - b_d < p_d < \theta v - b_d \\ v - b_r, & p_d \geq v\theta - b_d \end{cases} \quad (3.34)$$

$$p_d^* = \begin{cases} w, & p_r < v + w - v\theta + b_d - b_r - c_d + c_r \\ \frac{1}{2}\left(-v + w + v\theta - b_d + b_r + c_d - c_r + p_r\right), & v + w - v\theta + b_d - b_r - c_d + c_r \le p_r < v - w + \theta v - b_d - b_r - c_d + c_r \\ \theta v - b_d, & v - w + \theta v - b_d - b_r - c_d + c_r \le p_r < v \end{cases}$$

(3.28)

After finding the intersections of equation 3.34 and 3.28, the Nash equilibrium results of online direct and offline retail price are derived as same as equation 3.35 and 3.36 respectively.

$$p_d^N = \mathrm{w} \quad (3.35)$$

$$p_r^N = (1-\theta)v + b_d - b_r + w \quad (3.36)$$

Summary

Based on the above analysis under six different conditions, the Nash equilibrium is the results of prices, demands and profits in scenario 2 and are concluded as follows:

(1) When $(1-\theta)v + b_d < 2b_r$ and $b_d + b_r + c_d - c_r + (1-\theta)v > \frac{3}{2}(v-w)$ are satisfied, the p_d^N and p_r^N are derived as equation 3.30 and 3.31 respectively.

$$p_d^N = w + \frac{1}{3}\left(-b_d + 2b_r + 2c_d - 2c_r - (1-\theta)v\right) \quad (3.30)$$

$$p_r^N = w + \frac{1}{3}\left(b_d + b_r + c_d - c_r + (1-\theta)v\right) \quad (3.31)$$

After applying the equation 3.30 and 3.31 into equation 3.11 and 3.19, the Nash equilibrium results of demand for offline retail channel Q_r^N and Nash equilibrium results of demand for online direct channel Q_d^N are presented as equation 3.37 and 3.38 respectively. In this situation, cargo owners exist on both online direct and offline retail channels.

$$Q_r^N = \frac{b_d + b_r + c_d - c_r + (1-\theta)v}{3b_r} \quad (3.37)$$

$$Q_d{}^N = \frac{-b_d + 2b_r - c_d + c_r - (1-\theta)v}{3b_r} \tag{3.38}$$

Moreover, after applying the equation 3.30, 3.31, 3.37 and 3.38 into equation 3.3 and 3.4, the Nash equilibrium results of profit for the NVOCC/freight forwarder $\pi_r{}^N$ and the container shipping company $\pi_m{}^N$ are presented as equation 3.39 and 3.40 respectively.

$$\pi_r{}^N = \frac{(b_d + b_r + c_d - c_r + (1-\theta)v)^2}{6b_r} \tag{3.39}$$

$$\pi_m{}^N = \frac{b_d^2 + 4b_r^2 + b_r\left(-4v + 9w + 4v\theta - 4c_d - 5c_r\right) + \left(v - v\theta + c_d - c_r\right)^2 - 2b_d\left(-v + v\theta + 2b_r - c_d + c_r\right)}{9b_r} \tag{3.40}$$

(2) When $(1-\theta)v + b_d < 2b_r$ and $b_d + b_r + c_d - c_r + (1-\theta)v < \frac{3}{2}(v-w)$ are satisfied, $p_d{}^N$ and $p_r{}^N$ are derived as equation 3.32 and 3.33 respectively.

$$p_d{}^N = \theta v - b_d \tag{3.32}$$

$$p_r{}^N = \frac{v+w}{2} \tag{3.33}$$

After applying the equation 3.32 and 3.33 into equation 3.11 and 3.19, $Q_r{}^N$ and $Q_d{}^N$ are presented as equation 3.41 and 3.42 respectively. In this situation, cargo owners exist on both online direct and offline retail channels.

$$Q_r{}^N = \frac{v-w}{2b_r} \tag{3.41}$$

$$Q_d{}^N = \frac{2b_r - v + w}{2b_r} \tag{3.42}$$

Moreover, after applying the equation 3.32, 3.33, 3.41 and 3.42 into equation 3.3 and 3.4, the $\pi_r{}^N$ and $\pi_m{}^N$ are presented as equation 3.43 and 3.44 respectively.

$$\pi_r^N = \frac{(v-w)^2}{4b_r} \tag{3.43}$$

$$\pi_m^N = \frac{(-v+w+2b_r)(\theta v-b_d-c_d)+(v-w)(w-c_r)}{2b_r} \tag{3.44}$$

(3) When $(1-\theta)v+b_d \geq 2b_r$ is satisfied, p_d^N and p_r^N are derived as equation 3.35 and 3.36 respectively. In this situation, cargo owners exist on both online direct and offline retail channels.

$$p_d^N = w \tag{3.35}$$

$$p_r^N = (1-\theta)v + b_d - b_r + w \tag{3.36}$$

After applying the equation 3.35 and 3.36 into equation 3.11 and 3.19, Q_r^N and Q_d^N are presented as equation 3.45 and 3.46 respectively. This is the situation that the cargo owner only exists on online direct channel.

$$Q_r^N = 1 \tag{3.45}$$

$$Q_d^N = 0 \tag{3.46}$$

Moreover, after applying the equation 3.35, 3.36, 3.45 and 3.46 into equation 3.3 and 3.4, the π_r^N and π_m^N are presented as equation 3.47 and 3.48 respectively.

$$\pi_r^N = (1-\theta)v + b_d - b_r \tag{3.47}$$

$$\pi_m^N = w - c_r \tag{3.48}$$

3.6. Summary

In chapter 3, a conceptual dual-channel supply chain in CSI is established as the first research objective. Then seven influencing factors are selected as the independent variables and inputs of the models of profits for the container shipping company and the NVOCC/freight forwarder. Meanwhile, the consumer utility theory and Nash equilibrium theory are applied to construct the models and derive the Nash equilibrium results of prices, demands and profits for the container shipping company and the NVOCC/freight forwarder. The Nash equilibrium results of online direct price are exactly the pricing strategy proposed for the container shipping company. Moreover, the numerical examples in next chapter are conducted based on the derived Nash equilibrium results in this chapter.

Chapter 4 : NUMERICAL EXAMPLES, FINDINGS AND IMPLICATIONS

Based on the results of chapter 3, numerical examples of models are conducted in this chapter to verify the impacts of changes of specific independent variables on the Nash equilibrium results: demand, optimal prices and profits for the container shipping company and the NVOCC/freight forwarder. Moreover, the findings of numerical examples and correspondent implications for the container shipping company are discussed in depth. This chapter is organized as the following three sections.

In the first section, explanations of variables assignment are made. Variables assignment is the first step of numerical examples. In order to make the dissertation more valuable and useful for the decision-making of container shipping companies, the independent variables are assigned with reference to real market data from the CSI. In the second section, the effects of changing online unit cost c_d and consumer preference for online direct channel θ on pricing strategy and profits are analysed with specific variables assignment. After that, the findings and implications are concluded for the numerical examples. Similarly, in the third section, the effects of changing offline unit cost c_r, wholesale price w and valuaction v are put forwarded; pricing strategy and profits are discussed with specific variables assignment. The findings and implications are also summarized correspondingly.

4.1 Explanations of variables assignment

Combined with the explanations of the independent variables in chapter 3, the meaning and assignment of independent variables in a specific container liner service are discussed here. Furthermore, an international container shipping company operating both main trucking routes and continental trade lines provides the related data of the route from the Far East to North Europe.

(1) v represents consumers' ideal assumption of the utility of unit container shipping service, and it is simplified as the sum of the average long-term freight and assumed online consumers purchase cost in a specific route.

(2) w means the average wholesale price offered by the container shipping company to the NVOCC/freight forwarder. The margin between w and v is small in CSI because of the more transparent market and more severe competition. Normally, the NVOCC/freight forwarder expects to earn more through the other shipping supporting activities.

(3) θ represents the cargo owners' preference for online direct channel, and is assumed to change from zero to one ($\theta \in (0, 1)$).

(4) $\mathrm{c_d}$ represents the estimated average unit slot cost calculated by the container shipping company. In CSI, the unit slot cost $\mathrm{c_d}$ is close to the wholesale price w because of the overcapacity and intense competition. What is more, the gap between $\mathrm{c_d}$ and w will be shortened by low slot utility of containerships. Sometimes $\mathrm{c_d}$ is even greater than w in some specific routes for international container shipping companies, who want to provide world network service to cargo owners even if losing money on that route.

(5) $\mathrm{c_r}$ is assumed to change in a specific interval which contains the following situations.

a. When assuming online unit cost is greater than offline unit cost ($\mathrm{c_r} < \mathrm{c_d}$), the container shipping company acts as the pioneer in the emerging stage of e-commerce in CSI. The beginning IT and technology investment lead to high online unit cost $\mathrm{c_d}$. In this situation, the margin between $\mathrm{c_d}$ and $\mathrm{c_r}$ is relatively large. The margin between $\mathrm{c_d}$ and $\mathrm{c_r}$ depends on how much the container shipping company invest in the opening selling channel.

b. When assuming that online unit cost equals offline unit cost ($\mathrm{c_r} = \mathrm{c_d}$), the e-commerce in the container liner industry enters into the growing stage. More container shipping companies and cargo owners can join the online direct channel in this situation.

c. When assuming that online unit cost is lower than offline unit cost ($c_r > c_d$), e-commerce in the container liner industry is in the mature stage. In this situation, the margin between online unit cost and offline unit cost depends on the extent of competition in a specific route. The more intense the competition, the more rebate the container shipping company pays to the NVOCC/freight forwarder on the offline retail channel. The rebate can be saved on the online direct channel because the container shipping company can approach to cargo owner directly. Therefore, the more intense the competition, the higher margin between online and offline unit costs.

(6) b_r and b_d are consumer offline and online purchase costs. There are no related articles addressing consumer purchase costs in CSI, and related data from cargo owners cannot be obtained. Therefore, b_r and b_d can only be assigned with an estimated value. It can be assumed that online purchase cost is lower than offline purchase cost $b_r > b_d$. The first reason is that searching costs for container shipping services and negotiating costs can be saved for cargo owners because of the price transparency on the online direct channel. The second reason is that implementation cost can be saved because cargo owners can approach container shipping companies directly. In addition, the margin between b_d and b_r is relatively small because the characteristics of the service supply chain as discussed in chapter 3.

Based on the explanations of independent variables, numerical examples are conducted with specific assignment in the following sections.

4.2. The effects of online unit cost and consumer preference for online direct channel on pricing strategy and profits

In this part, the effects of online unit cost c_d and consumer preference for online direct channel θ on pricing strategy and profits are examined firstly through numerical examples. Then the corresponding findings and implications for container shipping company are also concluded and put forward.

4.2.1. Numerical examples

With reference to the data provided by an international container shipping company, online unit cost c_d and consumer preference for online direct channel θ are assigned with a specific interval and other independent variables are assigned with specific values as follows:

$v = 1560, b_r = 100, b_d = 50, c_r = 1200, w = 1400$

According to the results of Nash equilibrium, the cargo owners exist in both online and offline channels when $w < \theta v - b_d$ is satisfied. After calculating with the specific values, the cargo owners exist on both online and offline channels only when $\theta > 0.968$ is satisfied.

1. $\theta \in (0, 0.962)$

The cargo owners only purchase the shipping service through the offline retail channel in this situation. The Nash equilibrium of prices and profits are not affected by θ and c_d where $\theta \in (0, 0.962)$ according to equation 3.18. The Nash equilibrium results can be calculated as follows through equation 3.29 and 3.30.

$p_r^{off} = 1460 \quad Q_r^{off} = 1 \quad \pi_r = 60 \quad \pi_m = 200$

2. $\theta \in (0.962, 1)$

In this situation, the Nash equilibrium of prices and profits will be affected by θ and c_d according to equation 3.39, 3.40, 3.43 and 3.44. The Matlab R2016a is applied to do the numerical examples with the following assignment: $c_d \in (1000, 1400)$ and $\theta \in (0.962, 1)$. Howerver, there are some invalid values which do not comply with the assumptions in Nash equilibrium results. The online demand Q_d^N is less than zero and offline demand Q_r^N is greater than one when $c_d \in (1270, 1400)$ and $\theta \in (0.962, 0.968)$. Therefore, the interval of c_d and θ are adjusted as follows to remove those invalid values. The programming contents of Matlab for the numerical examples here are listed in appendix A.

$c_d \in (1000, 1270)$

$\theta \in (0.968, 1)$.

(1) The effects of c_d and θ on $Q_d{}^N$ and $Q_r{}^N$

The Nash equilibrium results of demand for online direct channel $Q_d{}^N$ are presented in Table 3. Figure 15 shows the effects of c_d and θ on $Q_d{}^N$.

a. When c_d increases in the interval: $c_d \in (1000, 1200)$, $Q_d{}^N$ is a constant ($Q_d{}^N = 0.2$) with c_d and θ.

b. When c_d increases in the next interval: $c_d \in (1200, 1270)$, $Q_d{}^N$ is inversely corrected with c_d, while positivle corrected with θ. $Q_d{}^N$ finally falls from 0.2 to 0 where $c_d = 1270$ and $\theta = 0.968$.

c. $Q_d{}^N$ will reduce to zero When c_d increase to $c_d = 1275$ and $\theta = 0.968$.

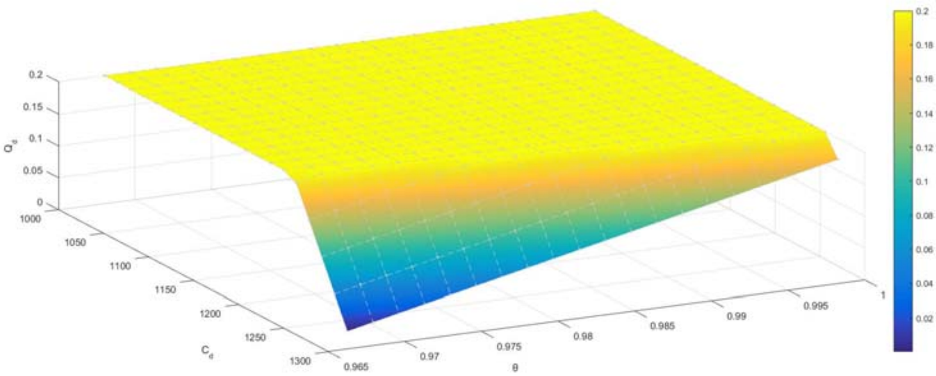


Figure 15. Effects of c_d and θ on $Q_d{}^N$

Table 3. $Q_d{}^N$ under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.19	0.14	0.10	0.05	0.00
0.969684	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.15	0.10	0.06	0.01
0.971368	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.16	0.11	0.07	0.02
0.973053	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.17	0.12	0.07	0.03
0.974737	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.18	0.13	0.08	0.04
0.976421	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.19	0.14	0.09	0.04
0.978105	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.19	0.15	0.10	0.05
0.979789	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.16	0.11	0.06
0.981474	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.17	0.12	0.07
0.983158	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.17	0.13	0.08
0.984842	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.18	0.14	0.09
0.986526	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.19	0.14	0.10
0.988211	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.15	0.11
0.989895	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.16	0.11
0.991579	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.17	0.12
0.993263	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.18	0.13
0.994947	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.19	0.14
0.996632	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.15
0.998316	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.16
1	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.17

$Q_r{}^N$ changes in the reverse way because of the conditon $Q_d + Q_r = 1$. The Nash equilibrium results of demand for online direct channel $Q_r{}^N$ are presented in Table 4. Figure 16 shows the effects of c_d and θ on $Q_r{}^N$.

a. When c_d increases in the interval: $c_d \in (1000, 1200)$, ${Q_r}^N$ is a constant (${Q_r}^N = 0.8$) with c_d and θ.

b. When c_d increases in the next interval: $c_d \in (1200, 1270)$, ${Q_r}^N$ is positively corrected with c_d, while ${Q_r}^N$ is inversely corrected with θ. ${Q_r}^N$ finally increases from 0.8 to 1 where c_d =1270 and $\theta = 0.968$.

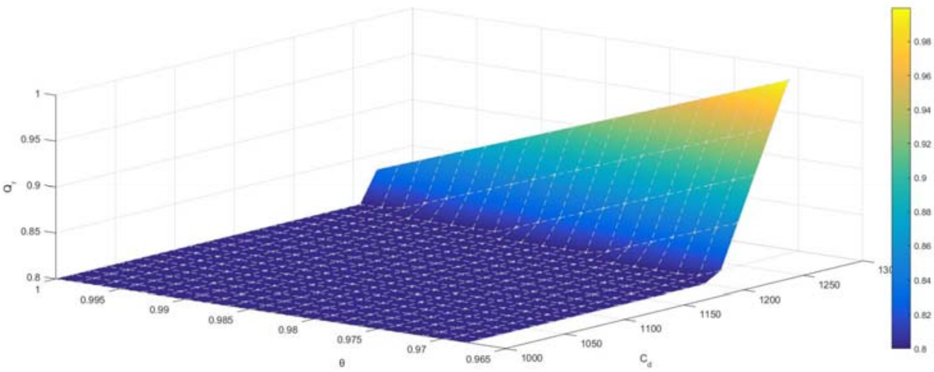


Figure 16. Effects of c_d and θ on ${Q_r}^N$

Table 4. ${Q_r}^N$ under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81	0.86	0.90	0.95	1.00
0.969684	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.85	0.90	0.94	0.99
0.971368	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.84	0.89	0.93	0.98
0.973053	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.83	0.88	0.93	0.97
0.974737	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.82	0.87	0.92	0.96
0.976421	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81	0.86	0.91	0.96
0.978105	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81	0.85	0.90	0.95
0.979789	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.84	0.89	0.94
0.981474	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.83	0.88	0.93
0.983158	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.83	0.87	0.92
0.984842	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.82	0.86	0.91
0.986526	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81	0.86	0.90
0.988211	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.85	0.89
0.989895	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.84	0.89
0.991579	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.83	0.88
0.993263	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.82	0.87
0.994947	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.81	0.86
0.996632	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.85
0.998316	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.84
1	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.83

The comparative findings of ${Q_r}^N$ and ${Q_r}^N$ can be concluded as Table 5. c_d and θ do not affect the Nash equilibrium results of demand for online direct and offline retail channels when $c_d \in (1000, 1200)$. ${Q_d}^N$ decreases to zero and ${Q_r}^N$ increases to one when c_d rises from 1200 to 1270.

Table 5. Effects of c_d and θ on Q_r^N and Q_d^N

	$c_d \in (1000, 1200)$ $\theta \in (0.968, 1)$		$c_d \in (1200, 1270)$ $\theta \in (0.968, 1)$	
Q_d^N	Q_d^N and c_d	Constant	Q_d^N and c_d	-
	Q_d^N and θ	Constant	Q_d^N and θ	+
Q_r^N	Q_r^N and c_d	Constant	Q_r^N and c_d	+
	Q_r^N and θ	Constant	Q_r^N and θ	-

(2) The effects of c_d and θ on p_d^N and p_r^N

The Nash equilibrium results of the online direct price for the container shipping company $Q_d^N$are presented in Table 6. Figure 17 shows the effects of c_d and θ on p_d^N.

a. When c_d increases in the interval: $c_d \in (1000, 1200)$, p_d^N is a constant with c_d and positively corrected with θ. p_d^N increases from 1430 to 1480 when θ increases from 0.968 to 1.

b. When c_d increases in the next interval: $c_d \in (1200, 1270)$, p_d^N increases with c_d and θ. p_d^N finally increases to 1486 where $c_d = 1270$ and $\theta = 1$.

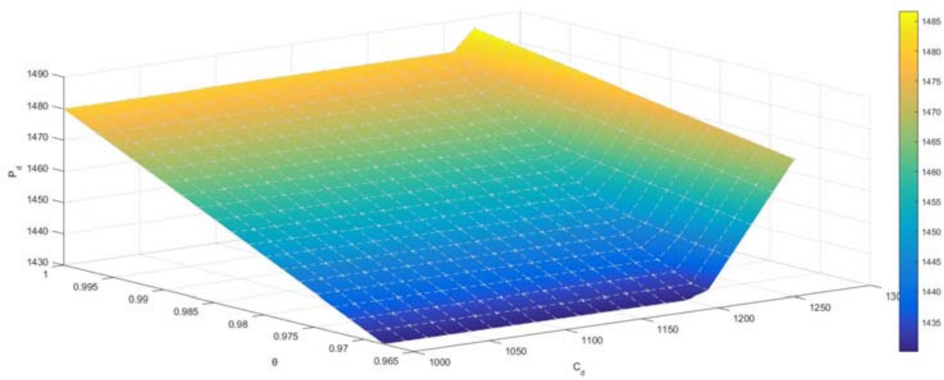


Figure 17. Effects of c_d and θ on p_d^N

Table 6. $p_d{}^N$ under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1430.08	1432.13	1441.61	1451.08	1460.55	1470.03
0.969684	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1432.71	1433.01	1442.48	1451.96	1461.43	1470.90
0.971368	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1435.33	1443.36	1452.83	1462.30	1471.78
0.973053	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1437.96	1444.23	1453.71	1463.18	1472.65
0.974737	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1440.59	1445.11	1454.58	1464.06	1473.53
0.976421	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1443.22	1445.98	1455.46	1464.93	1474.41
0.978105	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1445.84	1446.86	1456.33	1465.81	1475.28
0.979789	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1448.47	1457.21	1466.68	1476.16
0.981474	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1451.10	1458.09	1467.56	1477.03
0.983158	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1453.73	1458.96	1468.44	1477.91
0.984842	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1456.35	1459.84	1469.31	1478.78
0.986526	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1458.98	1460.71	1470.19	1479.66
0.988211	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1461.61	1471.06	1480.54
0.989895	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1464.24	1471.94	1481.41
0.991579	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1466.86	1472.81	1482.29
0.993263	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1469.49	1473.69	1483.16
0.994947	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1472.12	1474.57	1484.04
0.996632	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1474.75	1475.44	1484.92
0.998316	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1477.37	1485.79
1	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1486.67

The Nash equilibrium results of profits of offline retail price for NVOCC/freight forwarder $p_r{}^N$ are presented in Table 7. Figure 18 shows the effects of c_d and θ on $p_r{}^N$.

a. When c_d increases in the interval: $c_d \in (1000, 1200)$, $p_r{}^N$ is a constant with c_d and θ ($p_d{}^N = 1480$).

b. When c_d increases in the next interval: $c_d \in (1200, 1270)$, $p_r{}^N$ increases with c_d but decreases with θ. $p_r{}^N$ finally rise to 1500 where $c_d = 1200$ and $\theta = 0.968$.

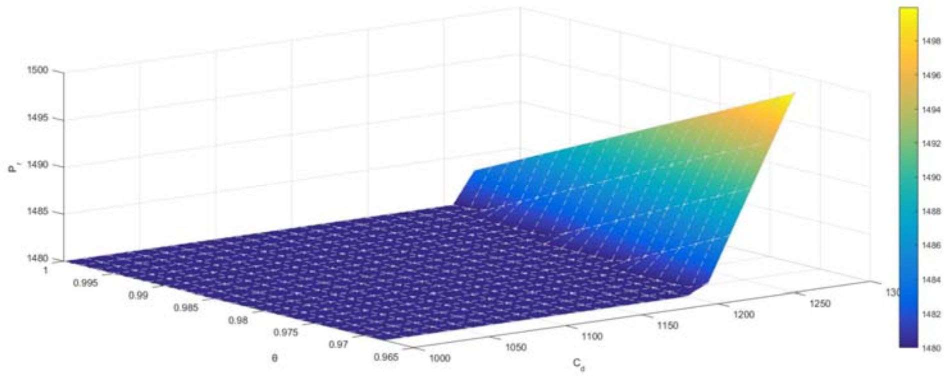


Figure 18. Effects of c_d and θ on $p_r{}^N$

Table 7. p_r^N under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1481.03	1485.76	1490.50	1495.24	1499.97
0.969684	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.15	1484.89	1489.62	1494.36	1499.10
0.971368	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1484.01	1488.75	1493.48	1498.22
0.973053	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1483.14	1487.87	1492.61	1497.35
0.974737	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1482.26	1487.00	1491.73	1496.47
0.976421	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1481.38	1486.12	1490.86	1495.59
0.978105	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.51	1485.24	1489.98	1494.72
0.979789	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1484.37	1489.11	1493.84
0.981474	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1483.49	1488.23	1492.97
0.983158	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1482.62	1487.35	1492.09
0.984842	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1481.74	1486.48	1491.22
0.986526	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.87	1485.60	1490.34
0.988211	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1484.73	1489.46
0.989895	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1483.85	1488.59
0.991579	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1482.98	1487.71
0.993263	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1482.10	1486.84
0.994947	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1481.22	1485.96
0.996632	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.35	1485.08
0.998316	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1484.21
1	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1483.33

The comparative findings of p_r^N and p_d^N can be concluded as Table 8. For container shipping company, p_d^N is positively correlated with θ but not affected by c_d when $c_d \in (1000, 1200)$. p_d^N is positively correlated with both c_d and θ when $c_d \in (1200, 1270)$. For NVOCC/freight forwardor, p_r^N is not affected by both c_d and θ when $c_d \in (1000, 1200)$. p_r^N is positively correlated with c_d but inversely correlated with θ when $c_d \in (1200, 1270)$.

Table 8. Effects of c_d and θ on p_r^N and p_d^N

	$c_d \in (1000, 1200)$ $\theta \in (0.968, 1)$		$c_d \in (1200, 1270)$ $\theta \in (0.968, 1)$	
p_d^N	p_d^N and c_d	Constant	p_d^N and c_d	+
	p_d^N and θ	+	p_d^N and θ	+
p_r^N	$p_r^N$and c_d	Constant	$p_r^N$and c_d	+
	p_r^N and θ	Constant	p_r^N and θ	-

(3) The effects of c_d and θ on π_m^N, π_r^N and π_{sc}^N

The Nash equilibrium results of profit for container shipping company π_m^N are presented in Table 9. Figure 19 shows the effects of c_d and θ on π_m^N .

π_m^N is inversely correlated with c_d but positively correlated with θ when $c_d \in (1000, 1270)$. The maximum π_m^N is 256 where $c_d = 1000$ and $\theta = 1$. The minimum π_m^N is 200 where $c_d = 1270$ and $\theta = 0.968$.

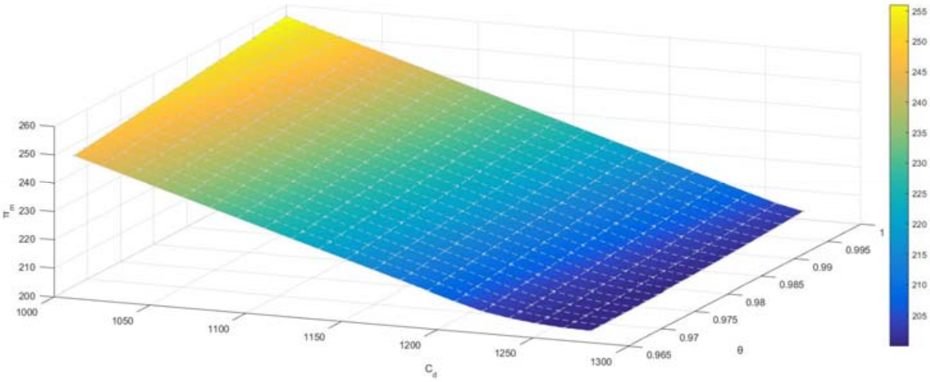


Figure 19. Effects of c_d and θ on $\pi_m{}^N$

Table 9. $\pi_m{}^N$ under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	246.02	243.17	240.33	237.49	234.65	231.81	228.96	226.12	223.28	220.44	217.59	214.75	211.91	209.07	206.23	203.60	202.03	200.90	200.23	200.00
0.969684	246.54	243.70	240.86	238.02	235.17	232.33	229.49	226.65	223.80	220.96	218.12	215.28	212.44	209.59	206.75	203.94	202.28	201.08	200.32	200.01
0.971368	247.07	244.22	241.38	238.54	235.70	232.86	230.01	227.17	224.33	221.49	218.65	215.80	212.96	210.12	207.28	204.44	202.56	201.27	200.42	200.03
0.973053	247.59	244.75	241.91	239.07	236.22	233.38	230.54	227.70	224.86	222.01	219.17	216.33	213.49	210.65	207.80	204.96	202.84	201.47	200.55	200.07
0.974737	248.12	245.28	242.43	239.59	236.75	233.91	231.07	228.22	225.38	222.54	219.70	216.85	214.01	211.17	208.33	205.49	203.15	201.69	200.68	200.12
0.976421	248.64	245.80	242.96	240.12	237.27	234.43	231.59	228.75	225.91	223.06	220.22	217.38	214.54	211.70	208.85	206.01	203.47	201.93	200.84	200.19
0.978105	249.17	246.33	243.48	240.64	237.80	234.96	232.12	229.27	226.43	223.59	220.75	217.91	215.06	212.22	209.38	206.54	203.80	202.18	201.00	200.28
0.979789	249.69	246.85	244.01	241.17	238.33	235.48	232.64	229.80	226.96	224.12	221.27	218.43	215.59	212.75	209.90	207.06	204.22	202.44	201.19	200.38
0.981474	250.22	247.38	244.54	241.69	238.85	236.01	233.17	230.33	227.48	224.64	221.80	218.96	216.11	213.27	210.43	207.59	204.75	202.72	201.39	200.49
0.983158	250.75	247.90	245.06	242.22	239.38	236.53	233.69	230.85	228.01	225.17	222.32	219.48	216.64	213.80	210.96	208.11	205.27	203.02	201.60	200.63
0.984842	251.27	248.43	245.59	242.74	239.90	237.06	234.22	231.38	228.53	225.69	222.85	220.01	217.17	214.32	211.48	208.64	205.80	203.33	201.83	200.77
0.986526	251.80	248.95	246.11	243.27	240.43	237.59	234.74	231.90	229.06	226.22	223.38	220.53	217.69	214.85	212.01	209.16	206.32	203.66	202.07	200.93
0.988211	252.32	249.48	246.64	243.80	240.95	238.11	235.27	232.43	229.58	226.74	223.90	221.06	218.22	215.37	212.53	209.69	206.85	204.01	202.33	201.11
0.989895	252.85	250.01	247.16	244.32	241.48	238.64	235.79	232.95	230.11	227.27	224.43	221.58	218.74	215.90	213.06	210.22	207.37	204.53	202.61	201.30
0.991579	253.37	250.53	247.69	244.85	242.00	239.16	236.32	233.48	230.64	227.79	224.95	222.11	219.27	216.43	213.58	210.74	207.90	205.06	202.90	201.51
0.993263	253.90	251.06	248.21	245.37	242.53	239.69	236.85	234.00	231.16	228.32	225.48	222.63	219.79	216.95	214.11	211.27	208.42	205.58	203.20	201.73
0.994947	254.42	251.58	248.74	245.90	243.06	240.21	237.37	234.53	231.69	228.84	226.00	223.16	220.32	217.48	214.63	211.79	208.95	206.11	203.53	201.97
0.996632	254.95	252.11	249.26	246.42	243.58	240.74	237.90	235.05	232.21	229.37	226.53	223.69	220.84	218.00	215.16	212.32	209.48	206.63	203.86	202.22
0.998316	255.47	252.63	249.79	246.95	244.11	241.26	238.42	235.58	232.74	229.90	227.05	224.21	221.37	218.53	215.69	212.84	210.00	207.16	204.32	202.49
1	256.00	253.16	250.32	247.47	244.63	241.79	238.95	236.11	233.26	230.42	227.58	224.74	221.89	219.05	216.21	213.37	210.53	207.68	204.84	202.78

The Nash equilibrium results of profit for the NVOCC/freight forwarder $\pi_r{}^N$ are presented in Table 10. Figure 20 shows the effects of c_d and θ on $\pi_r{}^N$.

a. When c_d increases in the interval: $c_d \in (1000, 1200)$, $\pi_r{}^N$ is a constant with c_d and θ ($\pi_r{}^N = 64$).

b. When c_d increases in the next interval: $c_d \in (1200, 1270)$, $\pi_r{}^N$ is positively correlated with c_d, but inversely corrected with θ. $\pi_r{}^N$ finally rises from 64 to 150 where $c_d = 1270$ and $\theta = 0.968$.

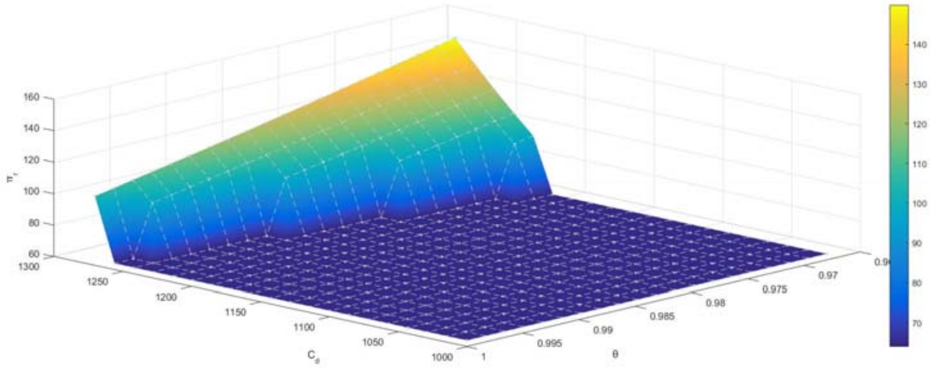


Figure 20. Effects of c_d and θ on $\pi_r{}^N$

Table 10. $\pi_r{}^N$ under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	98.48	110.33	122.85	136.05	149.92
0.969684	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	96.36	108.09	120.49	133.56	147.30
0.971368	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	105.87	118.14	131.09	144.71
0.973053	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	103.67	115.82	128.65	142.14
0.974737	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	101.50	113.53	126.23	139.60
0.976421	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	99.35	111.25	123.83	137.07
0.978105	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	97.22	109.00	121.45	134.57
0.979789	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	106.77	119.10	132.10
0.981474	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	104.57	116.77	129.64
0.983158	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	102.38	114.46	127.21
0.984842	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	100.23	112.18	124.80
0.986526	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	98.09	109.92	122.42
0.988211	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	107.68	120.06
0.989895	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	105.47	117.72
0.991579	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	103.27	115.40
0.993263	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	101.11	113.11
0.994947	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	98.96	110.84
0.996632	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	96.84	108.59
0.998316	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	106.37
1	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	64.00	104.17

The Nash equilibrium results of profit for the whole supply chain $\pi_{sc}{}^N$ are presented in Table 11. Figure 21 shows the effects of c_d and θ on $\pi_{sc}{}^N$.

a. When c_d increases in the interval: $c_d \in (1000, 1200)$, $\pi_{sc}{}^N$ is positively correlated with θ, but inversely corrected with c_d. Maximum $\pi_{sc}{}^N$ stands at 320 where $c_d = 1000$ and $\theta = 1$. Minimum $\pi_{sc}{}^N$ stands at 270 where $c_d = 1200$ and $\theta = 0.968$.

b. When c_d increases in the next interval: $c_d \in (1200, 1270)$, $\pi_r{}^N$ are positively correlated with c_d. However, the relation between $\pi_r{}^N$ and θ is not stable. In the beginning, $\pi_r{}^N$ is inversely corrected with θ when θ is low, but positively correlated with θ when θ is high. The positive relation becomes weak and weak when c_d increases. Finally, the relation between $\pi_r{}^N$ and θ becomes fully negative when c_d

increases to 1270. $\pi_r{}^N$ rises from 270 where $c_d = 1200$ and $\theta = 0.968$ to 350 where $c_d = 120$ and $\theta = 0.968$.

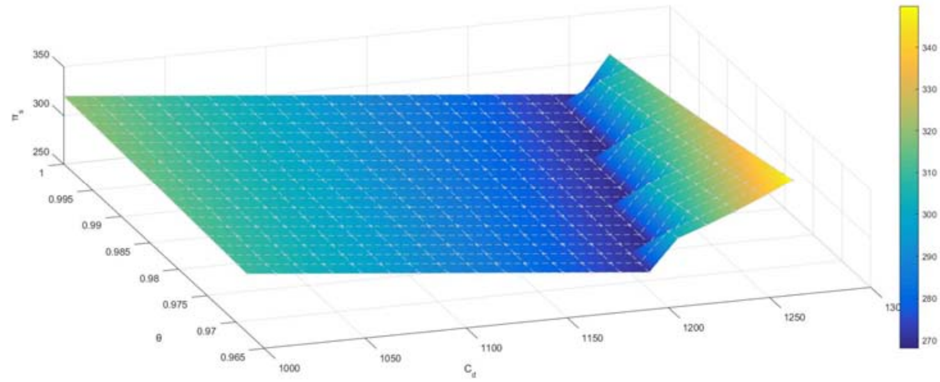


Figure 21. Effects of c_d and θ on $\pi_{sc}{}^N$

Table 11. $\pi_{sc}{}^N$ under various combinations of c_d and θ

θ \ Cd	1000	1014.211	1028.421	1042.632	1056.842	1071.053	1085.263	1099.474	1113.684	1127.895	1142.105	1156.316	1170.526	1184.737	1198.947	1213.158	1227.368	1241.579	1255.789	1270
0.968	310.02	307.17	304.33	301.49	298.65	295.81	292.96	290.12	287.28	284.44	281.59	278.75	275.91	273.07	270.23	302.08	312.36	323.76	336.28	349.92
0.969684	310.54	307.70	304.86	302.02	299.17	296.33	293.49	290.65	287.80	284.96	282.12	279.28	276.44	273.59	270.75	300.30	310.37	321.56	333.88	347.31
0.971368	311.07	308.22	305.38	302.54	299.70	296.86	294.01	291.17	288.33	285.49	282.65	279.80	276.96	274.12	271.28	268.44	308.42	319.41	331.52	344.74
0.973053	311.59	308.75	305.91	303.07	300.22	297.38	294.54	291.70	288.86	286.01	283.17	280.33	277.49	274.65	271.80	268.96	306.52	317.29	329.19	342.21
0.974737	312.12	309.28	306.43	303.59	300.75	297.91	295.07	292.22	289.38	286.54	283.70	280.85	278.01	275.17	272.33	269.49	304.65	315.22	326.91	339.72
0.976421	312.64	309.80	306.96	304.12	301.27	298.43	295.59	292.75	289.91	287.06	284.22	281.38	278.54	275.70	272.85	270.01	302.82	313.18	324.66	337.27
0.978105	313.17	310.33	307.48	304.64	301.80	298.96	296.12	293.27	290.43	287.59	284.75	281.91	279.06	276.22	273.38	270.54	301.02	311.18	322.45	334.85
0.979789	313.69	310.85	308.01	305.17	302.33	299.48	296.64	293.80	290.96	288.12	285.27	282.43	279.59	276.75	273.90	271.06	268.22	309.22	320.28	332.48
0.981474	314.22	311.38	308.54	305.69	302.85	300.01	297.17	294.33	291.48	288.64	285.80	282.96	280.11	277.27	274.43	271.59	268.75	307.29	318.15	330.14
0.983158	314.75	311.90	309.06	306.22	303.38	300.53	297.69	294.85	292.01	289.17	286.32	283.48	280.64	277.80	274.96	272.11	269.27	305.41	316.06	327.84
0.984842	315.27	312.43	309.59	306.74	303.90	301.06	298.22	295.38	292.53	289.69	286.85	284.01	281.17	278.32	275.48	272.64	269.80	303.56	314.01	325.58
0.986526	315.80	312.95	310.11	307.27	304.43	301.59	298.74	295.90	293.06	290.22	287.38	284.53	281.69	278.85	276.01	273.16	270.32	301.75	311.99	323.35
0.988211	316.32	313.48	310.64	307.80	304.95	302.11	299.27	296.43	293.58	290.74	287.90	285.06	282.22	279.37	276.53	273.69	270.85	268.01	310.01	321.17
0.989895	316.85	314.01	311.16	308.32	305.48	302.64	299.79	296.95	294.11	291.27	288.43	285.58	282.74	279.90	277.06	274.22	271.37	268.53	308.07	319.02
0.991579	317.37	314.53	311.69	308.85	306.00	303.16	300.32	297.48	294.64	291.79	288.95	286.11	283.27	280.43	277.58	274.74	271.90	269.06	306.17	316.91
0.993263	317.90	315.06	312.21	309.37	306.53	303.69	300.85	298.00	295.16	292.32	289.48	286.63	283.79	280.95	278.11	275.27	272.42	269.58	304.31	314.84
0.994947	318.42	315.58	312.74	309.90	307.06	304.21	301.37	298.53	295.69	292.84	290.00	287.16	284.32	281.48	278.63	275.79	272.95	270.11	302.49	312.81
0.996632	318.95	316.11	313.26	310.42	307.58	304.74	301.90	299.05	296.21	293.37	290.53	287.69	284.84	282.00	279.16	276.32	273.48	270.63	300.70	310.82
0.998316	319.47	316.63	313.79	310.95	308.11	305.26	302.42	299.58	296.74	293.90	291.05	288.21	285.37	282.53	279.69	276.84	274.00	271.16	268.32	308.86
1	320.00	317.16	314.32	311.47	308.63	305.79	302.95	300.11	297.26	294.42	291.58	288.74	285.89	283.05	280.21	277.37	274.53	271.68	268.84	306.94

The comparative findings of $\pi_m{}^N$, $\pi_r{}^N$ and $\pi_{sc}{}^N$ can be concluded as Table 12. θ is positively correlated with the profit of the container shipping company but inversely correlated with the profit of the NVOCC/freight forwarder. The relation between θ and $\pi_{sc}{}^N$ is changing when c_d changes. The original positive relation finally changes into positive relation. c_d is inversely correlated with the profits of the container shipping company and the whole supply chain. c_d have no affect to the profit of the NVOCC/freight forwarder when $c_d \in (1000, 1200)$, but c_d is positively correlated with the profit of the NVOCC/freight forwarder when $c_d \in (1200, 1270)$.

Table 12. Effects of c_d and θ on $\pi_m{}^N$, $\pi_r{}^N$ and $\pi_{sc}{}^N$

<table>
<tr><td></td><td colspan="2">$c_d \in (1000, 1200)$
$\theta \in (0.968, 1)$</td><td colspan="2">$c_d \in (1200, 1270)$
$\theta \in (0.968, 1)$</td></tr>
<tr><td rowspan="2">$\pi_m{}^N$</td><td>$p_r{}^N$ and c_d</td><td colspan="3">-</td></tr>
<tr><td>$p_r{}^N$ and θ</td><td colspan="3">+</td></tr>
<tr><td rowspan="2">$\pi_r{}^N$</td><td>$\pi_r{}^N$ and c_d</td><td>Constant</td><td>$\pi_r{}^N$ and c_d</td><td>+</td></tr>
<tr><td>$\pi_r{}^N$ and θ</td><td>Constant</td><td>$\pi_r{}^N$ and θ</td><td>-</td></tr>
<tr><td rowspan="2">$\pi_{sc}{}^N$</td><td>$\pi_{sc}{}^N$ and c_d</td><td colspan="3">-</td></tr>
<tr><td>$\pi_{sc}{}^N$ and θ</td><td colspan="3">+</td></tr>
</table>

4.2.2. Findings and implications

After implementing the numerical examples, the following questions are answered in this part as the implications for the container shipping company: When is the time for the container shipping company to emerge in e-commerce through the analysis of consumer preference for the online direct channel? How should the container shipping company set the optimal online direct price at different e-commerce evolvement stages with changing online unit cost c_d? With the development of e-commerce in CSI, the online unit cost c_d will be reduced. What are the impacts on the container shipping company's profit and optimal online direct price with decreasing online unit cost c_d?

1. The online direct channel has not yet been fully developed for container shipping company to enter into e-commerce.

According to the results of Nash equilibrium, the online direct channel will only exist when $w < \theta v - b_d$ is satisfied, which means the timing of opening the online direct channel depends on the values of v, θ, w and b_d. As dicussed in chapter 3, b_d is perceived by cargo owners and controlled by the third party, which will not be changed in a short term. Therefore, the Internet entry timing is decided by v, θ and w. The smaller margin between v and w, the higher θ is required to open the selling channel for the container shipping company. That is exactly the reality in CSI.

(1) The current situation of undeveloped online direct channel in CSI

As the previous calculation shows, it is only meaningful or profitable for the container shipping company to open the online direct channel on this route when $\theta > 0.968$. However, cargo owners' preference for the online direct channel is extremely low in the current situation. The reasons can be concluded as follows:

a. Long-term traditional purchasing habit or industry culture

The industry is known for a stubborn industry which relies on experiences and old beliefs. Container shipping is sensitive to the increment changes, especially when it becomes vulnerable due to its huge costs and investments. It also takes more time than other industries to recover. The cargo owners used to rely on NVOCC/freight forwarders for their business due to their long-term cooperative relationship. Cargo owners can count on NVOCC/freight forwarders for all shipping supporting logistic activities.

b. The insufficient investment from container shipping company

Container shipping companies were among the first to implement information and communication technology. Shipping companies tend to hesitate to move from business transaction to the Internet. EDI and Value-Added Networks required huge investment to establish. The change from one technology to another will lead to an obsolete of the prior one and the need of enormous financing. On the other hand, EDI is as inferior as the Internet in dealing with documentation and transactions. With respect to the large contract customers, the reliability and security of EDI may be more appropriate than the Internet.

In 2016, Cogziant (Setlur, Rajendran, & Ravi, 2016) conducted a survey on 30 interviewees from global freight forwarders, shipping agents, shipping liners and technology providers, to elucidate the barriers that hold back the emergence of e-commerce in shipping organizations. The respondents described some of the reasons are the priorities in their business competition, the lack of management understanding, the shortage of adequate IT infrastructure, the poor performance of implementation skills, no strong business care, and the concern about security (see Figure 22). To be more specific, the main reason for the slowdown of e-commerce to the shipping industry is the decision for investment which is critical to any shipping companies. It is challenging to justify whether e-commerce is crucial to invest and promising for profit returns. The shipping enterprises face a variety of competing priorities, for instance, procuring assets including containers, vessels, handling facilities and many other intensive capital-purchases. Shipping organizations are also challenged by the lack of adequate IT infrastructure and the skills for implementation.

Figure 22. The barriers for the adoption of e-commerce in container shipping companies

Source: Setlur et al. (2016)

The survey also reveals the operational challenges of the shipping organizations with e-commerce platform (see Figure 23). Sixty percent of the respondents illustrated that the lack of a standardized process results in the inefficient manual process in the organization. The issue of data quality together with personnel training and development are common obstacles to the adoption of an e-commerce platform. The lack of timely information accounts for some small proportion for that reason; however, it is also a critical point to address.

Figure 23. The operational challenges for adoption of e-commerce in container shipping companies
Source: Setlur et al. (2016)

A recent study conducted by Informa Engage, the sister company of Lloyd's List Container, shipping leaders were asked to grade the importance of digitalization in their respective businesses (Lloyd's List, 2019). Thirteen percent of the shipping leaders claimed that digital strategy is "extremely important" whilst 52% indicated that it is "very important". Especially, digital technology is listed as the top list of the solutions for all the major challenges and identified operation costs. In this survey, the respondents also identified the biggest barrier to invest in digitalization was the challenge in adopting new with existing technology. Fifteen percent of the respondents suspected about the suit of technology to their business. Others claimed that it takes time to pay back the investment which turn digitalization to be considered as a cost rather than an investment. It was emphasized in the research that shipping companies are keen on digitalization; however, they are not willing to invest. Other reasons include: security problems, lack of trust and lack of skills.

Similarly, container shipping lines integrated Electronic Data Interchange and extensive Electronic Data Processing systems in business operations. Nevertheless, e-commerce has not intensively been applied. Despite the fact that the majority of large shipping companies have their websites there are still barriers to implement a fully integrated e-commerce system.

c. **Dysfunctional online platform**

As mentioned in Table 1 of chapter 2, the top container shipping lines in the world, which account for an average of 85% of world container ship capacity, struggle to provide their customers with an e-commerce system to check for instant ocean freight. The notable e-commerce tools from the container shipping lines are Maersk Line with ship.maerskline.com and my.maerskline.com tools; CMA CGM with e-Business suite, Hapag-Lloyd's QuickQuotes tool. All the platforms require clients to register with username and passwords. It reflects a long way for clients to make use of the e-commerce tools in the shipping industry sector. Moreover, most carriers practically have no direct quoting or booking widget on their home pages. They are located in the "e-services" tab in the menu tools and require several mouse clicks to request a quote. Besides, more than half of the top 12 container lines create the functionality for rate quote request via electronic forms but hardly attempt to deliver instant quotes (Johnson, 2018). The customers do not only lack knowledge of IT but also currently get more challenges to struggle with the platform function. This results in the questions among the stakeholders, especially the small and medium sized companies about whether the carriers are interested in offering business transaction with online quoting platforms.

(2) The willingness of some container shipping companies to start the online direct channel in current situation

The emergence of e-booking creates a wide range of carriers for the selection of cargo owners. This is the essential factor for the automating ocean shipping. Looking at the current e-commerce activities in shipping company's systems which is represented in Figure 24, the EDI booking system is noteworthily at high degrees of automation while freight payment, documentation and vessel scheduling are particularly semi-automated.

	Fully Automated	Semi-Automated	Manual Process
Documentation (Bill of Lading (BOL), Notice of Arrival (NOA), etc.)	eBOL, shipping instructions updated via EDI, portal updates, electronic notifications and receipts.	Customers can fill out BOL forms through desktops, mobile devices and tablets.	BOL: Paper-based process. NOA via telephone, fax, e-mail, etc.
Rate Shopping	Quotations can be obtained online and later converted to orders.	Quotations can be obtained online with standard products/services.	Quotations are provided manually upon request by customers.
Vessel Schedules	Utilizes schedule consolidation engine to plan efficiently and accurately.	Manual planning of electronically received schedules from multiple carriers.	Manual process of gathering and aggregating schedule data.
Freight Payment	Freight bills are automatically validated and approved for payment. Automatic deduction of payment from customer's payment card, account or credit facility.	Ability to view the freight bills for shipments executed.	Manual pre-audits. Manual calculation of fuel surcharge and stop charges. Freight bills received through e-mail.
EDI Booking	Instant booking for qualifying transactions. Automatic notification of changes in booking status to third parties, including a confirmation message. Complete history for each booking, including a summary of critical changes.	Instant booking upon receiving file from customer. Confirmation sent to customer.	Manual creation of bookings. Modifications, amendments and confirmation manually prepared.

Figure 24. The level of automation in some critical functions
Source: Setlur et al. (2016)

In the mentioned survey (Setlur et al., 2016), the recognition of stakeholders to the importance of e-commerce as well as the adoption of it to the automating shipping processes are reflected in documentation and freight payments, rate shopping, shipment booking and vessel schedules. Container shipping companies struggle to not only maintain the ongoing business but also to keep track of updated innovative technologies. Shipping companies mostly use their website to offer several sophisticated services without more advanced business transactions. E-commerce has supported for efficiency improvements and cost reduction, said the representatives of Maersk in 2018 Sustainability Report (Maersk, 2018). In this report, Maersk also expected to achieve 30% of their revenues from e-commerce logistics from small and medium-sized customers by 2025.

It is challenging to foretell about the future use of the e-commerce in accordance with the development of the shipping industry when information and communication technology are changing drastically. Nevertheless, it is clear that the shipping companies will continue to develop in their own Internet-based portal to promote more sophisticated stages of e-commerce as an effective tool and prominent services for online booking, cargo tracking and tracing, and legal shipping documentation. INTTRA is undoubtedly a unique asset that strengthens the power of liner carriers.

Maritime transportation is characterized with enormous information flowing among parties involved. Essentially, information and communication technologies play a crucial role in the CSI. In a few years, more e-commerce volume is expected to be handled though shipping lines' portals due to an increase in the range of contract cargo being undertaken via Internet. However, shipping companies now process their bookings in different systems and formats (third party software or their own websites), and it turns out to be challenging for infomediary marketplaces to sustain the services. In this sense, buy-side e-commerce and third-party marketplaces tend to be dismissed to niche markets.

(3) The recommendations for the container shipping company to improve the cargo owners' preference for online direct channel

In order to promote e-commerce transformation in the container industry, a clear agenda with strategic vision needs to be obtained. CMA-CGM, Hapag-Lloyd and Maersk Line are the first enterprises with clear digital visions. Container shipping lines should consider these issues to develop and enhance the efficiency and effectiveness of online channels.

a. Develop a digital vision

No matter whether the carriers are the e-commerce leaders or the back-up followers, they essentially need a clear ambition and systematic vision for this transformation with the targeted goals and an implementation timeline. With the emergence of potential opportunities and risks, the carriers can take advantage of the chances and prioritize the selected actions-to-do.

b. Commit to rapid adoption

A rapid and bold digital adoption supports to develop a viable solution and create values for external and internal stakeholders. For example,

- Customer online experience: The online booking platform to prove instant quotes for the customers is intricated, notably for the shipments with intermodal transport. A resilient IT infrastructure with frequent updated dynamic price description for a variety of services and its quotations is crucial. It follows by real time reports of the conditions and locations of the shipments, particularly refrigerated cargo. A proper online experience for the customers is also the key point to raise the customer preference to online channels.

- Sale Force Effectiveness: The carriers can take advantage of the customer data which they have acquired to classify customers to segment and target the customer base. Thereby, the sales team are able to identify the individual demands and improve customer loyalty.

- Dynamic Pricing: Advanced analytics for a dynamically adjusting price system is essential. The carrier can take advantage of pricing engine with historical data to estimate the prompt pricing system according to the season with high demand or the utilization of the carriers for each journey. As reported, dynamic pricing can improve profits by 3 to 5% (Egloff, Sanders, Riedl, Mohottala & Georgaki, 2018).

c. Lay the foundation: The carriers should have a solid commitment to settle digital capabilities in the enterprises.

- Structure and processes: It is essential to have a cross-functional innovation team for the end-to-end digital transformation concentrates on the innovation of the project. KPIs and incentives should be set up for the entrepreneur's culture to acknowledge the risk and rewards for the successful ideas of innovation.

- People: Digital skills, especially IT, are necessary to build up e-commerce capabilities throughout support functions, commercial and operational. A mechanism to recruit talents such as data modeler, data scientist and web designer is needed in the competitive digital market.

- Data and systems: A modernized system with robust and comprehensive data and digital architecture which permits the IT and digital functions to accommodate with most-updated technologies should be available.

- Change management: A sharp and realistic approach to the new management is required to proceed digital technologies instead of the traditional work styles considering how the organization can accommodate and make sure that the digital adoption is sustained.

d. Develop outside the main organization

A distinct and separated team from the organization will assist ingenious offerings and discover creative ways to tackle the core operations of the organization. This build-operate-transfer-approach will spearhead the technology transformation for best-practice. A collaboration between both team's effort and corporate's operations will promote the pace of digitalization.

In conclusion, in order to gain in the digital era, the carrier must be willing to dedicate resources and time. Most carriers are still reluctant as they have no overall vision or imperative plans for the technology adoption. The carriers can conquer the barriers from organizational hurdles and the shortage of digital capabilities and skilled officers when they are dedicated to explore digital opportunities in depth. Besides, the Internet entry timing is decided by the cargo owners' preference for online direct channels. The container shipping company will also benefit from the online direct channel when the margin between w and v is increased. The effects of v and w on pricies and profits will also be analysed in the following section.

2. The container shipping company should adopt various pricing strategy in different e-commerce evolvement stages

The setting of online direct price should not be equal to offline retail price or be randomly decided. The random pricing strategy will definitely lead to serious results, such as customer and profit loss. The online direct price is dynamic with changing online unit cost. As discussed in chapter 3, the container shipping company has different online and offline unit costs in various e-commerce evolvement stages. It is regarded that the online unit cost will decrease with deeper e-commerce engagement.

After assigning a specific value for θ ($\theta = 0.98$), a new numerical example is conducted to examine the effects of c_d on Nash equilibrium results, as shown in Figure 25 and Table 13. The programming contents for the numerical example are listed in Appendix B. The container shipping company should adopt the online direct price in Nash equilibrium results if they aim to maximize the profit in a decentralized supply chain.

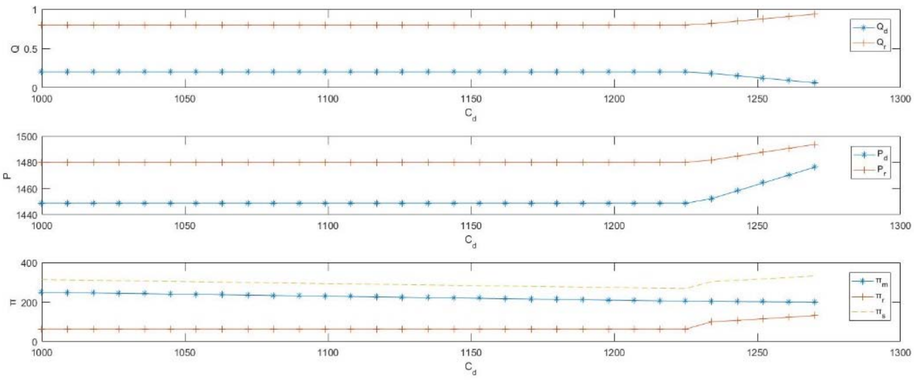


Figure 25. Effects of c_d on π, Q, P where $\theta = 0.98$

Table 13. Effects of c_d on π, Q, P where $\theta = 0.98$

Cd	1000	1009	1018	1027	1036	1045	1054	1063	1072	1081	1090	1099	1108	1117	1126
Pd	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8
Pr	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0
Qd	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Qr	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
πm	249.8	248.0	246.2	244.4	242.6	240.8	239.0	237.2	235.4	233.6	231.8	230.0	228.2	226.4	224.6
πr	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0
πs	313.8	312.0	310.2	308.4	306.6	304.8	303.0	301.2	299.4	297.6	295.8	294.0	292.2	290.4	288.6

Cd	1135	1144	1153	1162	1171	1180	1189	1198	1207	1216	1225	1234	1243	1252	1261	1270
Pd	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1448.8	1452.3	1458.3	1464.3	1470.3	1476.3
Pr	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1480.0	1481.7	1484.7	1487.7	1490.7	1493.7
Qd	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Qr	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
πm	222.8	221.0	219.2	217.4	215.6	213.8	212.0	210.2	208.4	206.6	204.8	203.3	202.3	201.5	200.9	200.4
πr	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	100.2	107.7	115.5	123.5	131.8
πs	286.8	285.0	283.2	281.4	279.6	277.8	276.0	274.2	272.4	270.6	268.8	303.5	310.0	317.0	324.3	332.2

(1) When c_d stands at 1270, which is exactly the current situation for the container shipping company ($c_d > c_r = 1200$), it is a dilemma. The high online unit cost is inevitable because of the huge initial investment on IT, and technology. If the container shipping company only aims to maximize the profit as is assumed here, the optimal online direct price has to be increased to compensate the high online unit cost. Correspondingly, the NVOCC/freight forwarder is also prone to increase the offline retail price. Finally, the cargo owners will move to other sellers because there are more than one container shipping company and NVOCC/freight forwarder in reality. For the container shipping company who acts as the pioneer of e-commerce in CSI, if they adopt the Nash equilibrium online direct price like this, they will definitely suffer

customer losses. Maximizing profit is, however, not their only goal. The container shipping company should be very prudent in setting the online direct price to balance the market share and profit. It seems inevitably for them to sacrifice some profits and even lose money initially if they insist on exploring the online direct channel in current situation.

(2) When c_d decreases in this interval $c_d \in (1225,1270)$, the Nash equilibrium results of online direct price also decrease. The profit of the container shipping company also rises slightly. Moreover, the Nash equilibrium results of online direct price are lower than offline retail price in this interval of c_d. The container shipping company competes with the NVOCC/freight forwarder in this situation through the online direct platform in this situation.

(3) When c_d decreases in this interval $c_d \in (1000,1225)$, the Nash equilibrium results of prices and demand for two channels are unchanged even if c_d keeps decreasing. The container shipping company can enjoy more profits because of the reduced online unit price and stable demand for the online direct channel.

4.3. The effects of consumers' valuation of container shipping service, wholesale price and unit cost on pricing strategy and profits

Though only the route from the Far East to North Europe has been considered as an example, the findings of this dissertation are still of importance. The reason is the main difference between various routes are just reflected on different margins among unit cost c_r, wholesale price w and consumers' valuaction v.

In order to simplify the numerical examples, it is assumed that online unit cost c_d equals offline unit cost c_r. Therefore, only offline unit cost c_r in chapter 4.3 is mentioned. Moreover, Variables θ, b_r and b_d are assigned with uniform value in chapter 4.3 as follows, and the other variables' assignment differs in scenarios.

$$\theta = 0.98, b_r = 100, b_d = 50, c_r = c_d$$

4.3.1. The effects of consumers' valuation of container shipping service and wholesale price on pricing strategy and profits

Two scenarios with changing margins wholesale price w and consumers' valuation v are analyzed. The realistic meanings in the CSI are: How should the container shipping company adjust the optimal online direct price when consumer' valuation v changes? What are the impacts on the online direct price and profit if wholesale price w shows no change or change in proportion at the same time?

1. Scenario 1: The market's fluctuation leads to the change of consumers' valuation of container shipping service v without fluctuation of wholesale price w and unit cost c_r. Related varibales are assigned as follows and the programming contents in matlab for this numerical example are listed in Appendix C.

$$v \in (1500, 1600),\ w = 1400,\ c_r = c_d = 1200$$

When the market goes up, it means that the cargo owners' estimated valuation of container shipping service increases, and vice versa. Figure 26 and Table 14 indicate the effects of v on the pricing strategy and profts.

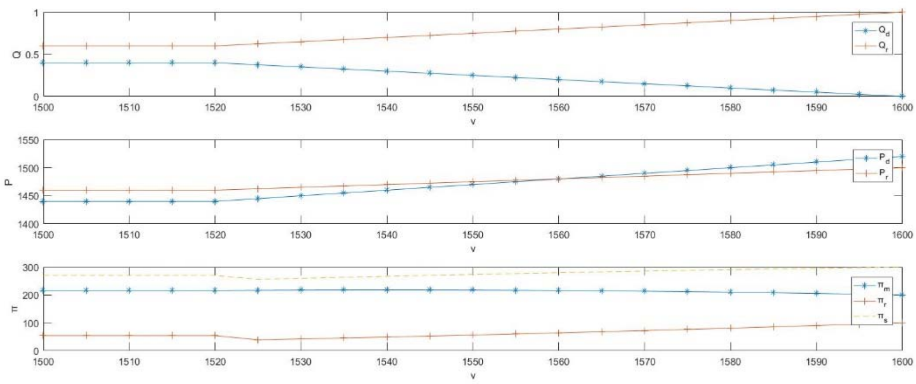


Figure 26. Effects of v on the pricing strategy and profits

Table 14. Effects of v on the pricing strategy and profits

v	1500	1505	1510	1515	1520	1525	1530	1535	1540	1545	1550	1555	1560	1565	1570	1575	1580	1585	1590	1595	1600
Pd	1440	1440	1440	1440	1440	1445	1450	1455	1460	1465	1470	1475	1480	1485	1490	1495	1500	1505	1510	1515	1520
Pr	1460	1460	1460	1460	1460	1462.5	1465	1467.5	1470	1472.5	1475	1477.5	1480	1482.5	1485	1487.5	1490	1492.5	1495	1497.5	1500
Q d	0.4000	0.4000	0.4000	0.4000	0.4000	0.3750	0.3500	0.3250	0.3000	0.2750	0.2500	0.2250	0.2000	0.1750	0.1500	0.1250	0.1000	0.0750	0.0500	0.0250	0.0000
Q r	0.6000	0.6000	0.6000	0.6000	0.6000	0.6250	0.6500	0.6750	0.7000	0.7250	0.7500	0.7750	0.8000	0.8250	0.8500	0.8750	0.9000	0.9250	0.9500	0.9750	1.0000
πm	216	216	216	216	216	216.875	217.5	217.875	218	217.875	217.5	216.875	216	214.875	213.5	211.875	210	207.875	205.5	202.875	200
πr	54	54	54	54	54	39.0625	42.25	45.5625	49	52.5625	56.25	60.0625	64	68.0625	72.25	76.5625	81	85.5625	90.25	95.0625	100
πs	270	270	270	270	270	255.938	259.75	263.438	267	270.438	273.75	276.938	280	282.938	285.75	288.438	291	293.438	295.75	297.938	300

(1) When the market goes down (v $\in (1500, 1560)$), the container shipping company and the NVOCC/freight forwarder both suffer profit losses. The optimal online and offline prices also drop when the market goes down. Though they change as was expected, the process of changes is complex, as explained below.

a. Optimal online direct price is lower than optimal offline retail price. Optimal online direct price decreases from 1480 to 1440 when v decreases in the interval (v $\in (1520, 1560)$). Then optimal online direct price becomes stable at 1440 even if v keeps dropping (v $\in (1500, 1520)$).

b. The demand for online direct channel increases from 0.2 to 0.4 when v decreases in the interval (v $\in (1520, 1560)$) and becomes stable at 0.4 when v keeps dropping (v $\in (1500, 1520)$).

c. The profit of container shipping company increases slightly from 216 to 218 when v decreases in the interval (v $\in (1540, 1560)$). However, it drops slightly from 218 to 216 when v keeps decreasing in the interval (v $\in (1520, 1540)$) and them stay stable at 216 when v keeps decreasing in the interval (v $\in (1500, 1520)$).

(2) When the market goes up (v $\in (1560, 1600)$), the optimal online and offline prices also increase as expected. However, both the container shipping company and the NVOCC/freight forwarder do not enjoy more profits from the increasing market as expected. The container shipping company even suffers profit loss. The process of changes is concluded as follows:

a. Optimal online direct price becomes greater than optimal offline retail price when market goes up. Optimal online direct price increases from 1480 to 1520 when v keeps rising in the interval (v $\in (1560, 1600)$).

b. The demand for online direct channel decreases from 0.2 to 0 when v decreases in the interval (v $\in (1560, 1600)$).

c. The profit of the container shipping company decreases from 216 to 200 when v decreases in the interval (v $\in (1540, 1560)$) . However, the profit of the NVOCC/freight forwarder increases from 64 to 100. The NVOCC/freight forwarder benefits from the increasing market because of the following reasons. The wholesale price offered by the container shipping company to the NVOCC/freight forwarder has not increased correspondingly, and the offline retail price is induced to increase because of the rise of the online direct price. Moreover, the profits of the whole supply chain will increase as expected.

2. Scenario 2: The market's fluctuation leads to the change of consumers' valuation of container shipping service v, and wholesale price w changes in proportion without change of units cost c_r. Related variables are assigned as follows and the programming contents in Matlab for this numerical example are listed in Appendix D.

$$v \in (1500, 1800),\ w = 14/15v,\ c_r = c_d = 1200$$

Different from scenario 1, the cargo owners' estimated valuation of container shipping service v and the wholesale price w which is offered by the container shipping company to the NVOCC/freight forwarder fluctuates in proportion. Figure 27 and Table 15 present the effects of v and w on the pricing strategy and proftis.

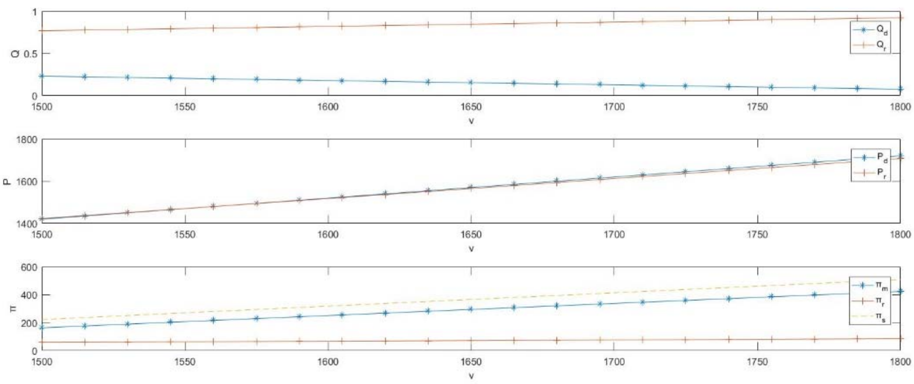


Figure 27. Effects of v and w on the pricing strategy and profits

Table 15. Effects of v and w on the pricing strategy and profits

v	1500	1515	1530	1545	1560	1575	1590	1605	1620	1635	1650
Pd	1420	1435	1450	1465	1480	1495	1510	1525	1540	1555	1570
Pr	1423.08	1437.31	1451.54	1465.77	1480	1494.23	1508.46	1522.69	1536.92	1551.15	1565.38
Qd	0.2231	0.2154	0.2077	0.2000	0.1923	0.1846	0.1769	0.1692	0.1615	0.1538	0.1462
Qr	0.7692	0.7769	0.7846	0.7923	0.8000	0.8077	0.8154	0.8231	0.8308	0.8385	0.8462
πm	163.195	176.432	189.645	202.834	216	229.142	242.26	255.355	268.426	281.473	294.497
πr	59.1716	60.3609	61.5621	62.7751	64	65.2367	66.4852	67.7456	69.0178	70.3018	71.5976
πs	222.367	236.793	251.207	265.609	280	294.379	308.746	323.101	337.444	351.775	366.095

v	1665	1680	1695	1710	1725	1740	1755	1770	1785	1800
Pd	1585	1600	1615	1630	1645	1660	1675	1690	1705	1720
Pr	1579.62	1593.85	1608.08	1622.31	1636.54	1650.77	1665	1679.23	1693.46	1707.69
Qd	0.1385	0.1308	0.1231	0.1154	0.1077	0.1000	0.0923	0.0846	0.0769	0.0000
Qr	0.8538	0.8615	0.8692	0.8769	0.8846	0.8923	0.9000	0.9077	0.9154	0.9231
πm	307.497	320.473	333.426	346.355	359.26	372.142	385	397.834	410.645	423.432
πr	72.9053	74.2249	75.5562	76.8994	78.2544	79.6213	81	82.3905	83.7929	85.2071
πs	380.402	394.698	408.982	423.254	437.515	451.763	466	480.225	494.438	508.639

(1) When the market goes down ($v \in (1500, 1560)$), the container shipping company and the NVOCC/freight forwarder both suffer profit losses. The optimal

online and offline prices also drop when the market goes down. All of them are changed as follows:

a. Optimal online direct price is lower than optimal offline retail price. Compared with scenario 1, the optimal online direct price decreases more remarkably from 1480 to 1420.

b. The demand for online direct channel increases slightly from 0.2 to 0.22.

c. The profit of the container shipping company decreases more largely from 216 to 163 when v decreases in the interval ($v \in (1500, 1560)$) when compared with scenario.

(2) When the market goes up ($v \in (1560, 1800)$), the optimal online and offline prices also increase as expected. However, both the container shipping company and the NVOCC/freight forwarder cannot enjoy more profits from the increasing market as expected. The container shipping company even suffers profit loss. The process of changes is concluded as follows.

a. Optimal online direct price becomes greater than the optimal offline retail price when the market goes up. Optimal online direct price increases from 1480 to 1720 when v keeps rising.

b. The demand for online direct channel decreases from 0.2 to 0 when v keeps increasing.

c. Both the container shipping company and the NVOCC/freight forwarder benefit from the increasing market because the wholesale price w increases with v in proportion.

4.3.2. The effects of unit cost and wholesale price on pricing strategy and profits

Similar to chapter 4.31, two scenarios changing margins between unit cost c_r and wholesale price w are put forward. The correspondent meanings in the CSI is how should the container shipping company adjust the optimal online direct price when the unit cost c_r is reduced or increased? What are the impacts on the online direct price and profit if wholesale price w has no change or change in proportion at the same time?

1. Scenario 1: Unit cost c_r change without fluctuation in the consumers' valuation of container shipping service v and wholesale price w

Lots of factors can reduce the unit cost in reality, such as the improvement of the slot utility of containerships and the reduction of the operating cost. Similarly, the reduction of slot utility of containerships and the increase of operating cost will increase the unit cost. Therefore, it is more meaningful to discuss the change of optimal price strategy and profits when unit cost fluctuates. Related variables are assigned as follows and the programming contents in Matlab for this numerical example are listed in Appendix E. Figure 28 shows the effects of c_r on the pricing strategy and profits.

$$v = 1560, w = 1400, c_r = c_d \in (1000,1300)$$

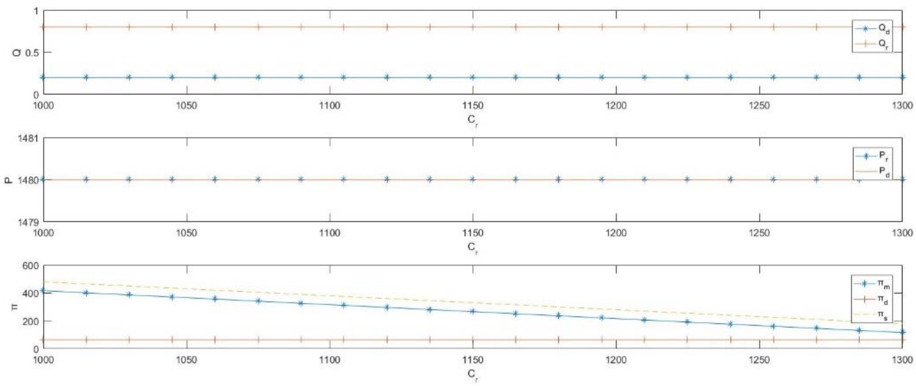


Figure 28. Effects of c_r on the pricing strategy and profits

It is apparent that NVOCC/freight forwarder is not affected in this scenario because of unchanged wholesale price and offline retail price. The optimal online direct price for container shipping company stays stable, which means there is no need for container shipping company to change the online direct price in this situation. The profit of container shipping company is positively correlated with the unit cost.

2. Scenario 2: **Unit cost c_r and w change in proportion without fluctuation in the consumers' valuation of container shipping service v.** Related variables are assigned as follows and the programming contents in Matlab for this numerical example are listed in appendix F.

$$v = 1560, w = \frac{14}{12} * c_r, c_r = c_d \in (1180,1260)$$

In contrast to scenario 1, the wholesale price w offered by contaienr shippping company to NVOCC/freight forwarder and unit cost c_r change in proportion. Figure 29 and Table 16 illustrate the effects of unit cost c_r and w on the pricing strategy and profits.

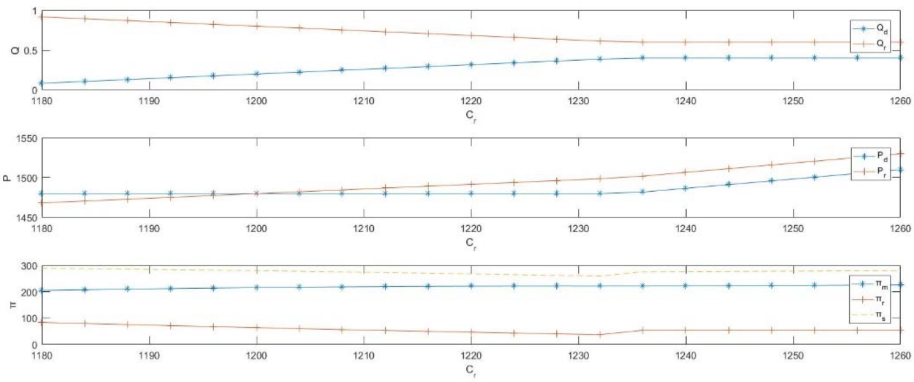


Figure 29. Effects of c_r and w on the pricing strategy and profits.

Table 16. Effects of c_r and w on the pricing strategy and profits.

Cr	1180	1184	1188	1192	1196	1200	1204	1208	1212	1216	1220
Pd	1480	1480	1480	1480	1480	1480	1480	1480	1480	1480	1480
Pr	1468.33	1470.67	1473	1475.33	1477.67	1480	1482.33	1484.67	1487	1489.33	1491.67
Qd	0.08333	0.10667	0.13	0.15333	0.17667	0.2	0.22333	0.24667	0.27	0.29333	0.31667
Qr	0.91667	0.89333	0.87	0.84667	0.82333	0.8	0.77667	0.75333	0.73	0.70667	0.68333
π_m	205.278	207.858	210.22	212.364	214.291	216	217.491	218.764	219.82	220.658	221.278
π_r	84.0278	79.8044	75.69	71.6844	67.7878	64	60.3211	56.7511	53.29	49.9378	46.6944
π_s	289.306	287.662	285.91	284.049	282.079	280	277.812	275.516	273.11	270.596	267.972

Cr	1224	1228	1232	1236	1240	1244	1248	1252	1256	1260
Pd	1480	1480	1480	1482	1486.67	1491.33	1496	1500.67	1505.33	1510
Pr	1494	1496.33	1498.67	1502	1506.67	1511.33	1516	1520.67	1525.33	1530
Qd	0.34	0.36333	0.38667	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Qr	0.66	0.63667	0.61333	0.6	0.6	0.6	0.6	0.6	0.6	0.6
π_m	221.68	221.864	221.831	222	222.667	223.333	224	224.667	225.333	226
π_r	43.56	40.5344	37.6178	54	54	54	54	54	54	54
π_s	265.24	262.399	259.449	276	276.667	277.333	278	278.667	279.333	280

When the unit cost is reduced ($c_r \in (1180, 1200)$), the changes of Nash equilibrium results are concluded as follows.

a. Different with the unchanged and equal optimal online direct and offline retail price. The optimal prices differ and change more obviously in this scenario. Optimal online direct price becomes lower than optimal offline retail channel when unit cost is increased. Optimal online direct price is unchanged when unit cost rise in the interval

($c_r \in (1200, 1232)$), but it starts to increase when unit cost increase in the interval ($c_r \in (1230, 1260)$).

b. The demand for online direct channel increases from 0.2 to 0.4 when unit cost increases in the interval: $c_r \in (1200, 1232)$. Then it becomes stable even if the unit cost keeps increasing in the interval: $c_r \in (1232, 1260)$.

c. In stark contrast to scenario 1, the Nash equilibriums results of profits do not change much. Container shipping company's profit increase and NVOCC/freight forwarder 's profit decreases when unit cost rises in the interval: $c_r \in (1200, 1260)$. The main reason is the proportionally changed wholesale price. Moreover, the profits of supply chain are reduced slightly in the interval: $c_r \in (1200, 1232)$ and improved slightly in the interval: $c_r \in (1232, 1260)$.

4.4. Summary

Based on the variable's assignment with reference to the data in CSI, the effects of five independent variables on the pricing strategy and profits are examined respectively by several numerical examples in this chapter.

In chapter 4.2, the effects of online unit cost and consumer preference for the online direct channel on the pricing strategy and profits were discussed. After conducting the numerical examples, the findings and implication for the container shipping company are summarized correspondingly. The results of numerical examples show that the container shipping company has not yet entered into the e-commerce because of the low consumer preference for the online direct channel right now. The reasons for the low preference are discussed and the recommendations for the improvement of preference are put forward. On the other hand, the results of numerical examples present the dynamic Nash equilibrium results of the online direct price under the changing online unit cost. The Nash equilibrium results of the online direct price were sometimes surprisingly different from expectation.

Chapter 4.3, discussed the effects of unit cost, consumers' valuation of container shipping services and wholesale price offered by the container shipping company to the NVOCC/freight forwarder on the pricing strategy and profits. Consumers' valuation of container shipping services reflects the fluctuation of the freight market in reality and it is a factor normally uncontrollable by the container shipping company. Two scenarios with changing consumers' valuation of container shipping services are put forward to reflect the fluctuation of freight in reality, and correspondent numerical examples are conducted. The results of numerical examples propose dynamic optimal online direct price for the container shipping company. Moreover, the results indicate that the container shipping company will not definitely benefit from the increasing market but may suffer the loss from the decreasing market if the wholesale price changes in proportion. Different from consumers' valuation of container shipping services, the container shipping company's unit cost is a factor more controllable by the container shipping company. Two scenarios with changing unit cost are put forward, and correspondent numerical examples are implemented. Similarly, the results of numerical examples propose dynamic optimal online direct price for the container shipping company. Moreover, the results indicate that the container shipping company will not definitely lose from the increasing unit cost but may benefit from the decreasing unit cost if the wholesale price changes in proportion.

In conclusion, the numerical examples verify that the optimal online direct price should be settled prudently considering all the independent variables. If the container shipping company sets the online direct price randomly or unreasonably, the profits and market share will suffer loss. The Nash equilibrium results propose the optimal online direct price as reference for the container shipping company's pricing strategy, which is exactly the significance of the dissertation.

Chapter 5

The main results, contribution and limitations of this dissertation are concluded in this chapter.

5.1. Summary

Firstly, the dissertation summarizes the prevailing research of pricing strategy in the dual-channel supply chain, especially the studies that apply the Nash equilibrium game theory and consumer utility theory. Based on that, related achievement and theories are applied in CSI. The four questions listed in chapter 1.2 are finally discussed and answered in chapter 3 and chapter 4.

In chapter 3.1 and 3.3.1, the first question listed in chapter 1.2 is answered: What are the factors influencing the pricing strategy and profits of container shipping company and NVOCC/freight forwarder in the decentralized dual-channel supply chain? Seven factors influencing the pricing strategy and profits of the container shipping company and the NVOCC/freight forwarder in a decentralize dual-channel supply chain in CSI are put forward and discussed in-depth. Furthermore, those seven influencing factors are used as the inputs of the profit models.

In order to answer the second question listed in chapter 1.2: What are the Nash equilibrium results of optimal online direct and offline retail prices for the container shipping company and the NVOCC/freight forwarder respectively in the decentralized dual-channel supply chain? The following work is fulfilled in chapter 3.3, 3.4 and 3.5. Firstly, the conceptual dual-channel supply chain with one container shipping company and one NVOCC/freight forwarder is established. Secondly, the optimization theory, the non-cooperative Nash equilibrium game theory and the consumer utility theory are applied synthetically to construct profit models for the container shipping company and the NCOCC/freight forwarder. Then, Nash equilibrium results of prices, demands and profits are derived. The Nash equilibrium results of the online direct price are the proposed pricing strategy for the container shipping company to maximize their profits in the dual-channel supply chain.

In chapter 4.2, the third question listed in chapter 1.2 is answered through several numerical examples: What are the implications of the Nash equilibrium results for a container shipping company? The findings indicated that the container shipping company would only benefit from the online direct channel when the cargo owners' preference for online channel is close to the traditional offline retail channel. Obviously, the online direct channel has not yet been developed for the container shipping company to enter into e-commerce because of low consumer preference for the online direct channel now. Container shipping companies cannot benefit from the online direct channel because of the high investment on the establishment of an online platform. Nevertheless, some container shipping companies act as the pioneers in the e-commerce evolvement progress because of the enormous advantages from the online channel such as the reduction in cost of sales, the access of all customers to container shipping companies (customer-oriented goal) and the structured data management via online transactions.

In order to answer the fourth question listed in chapter 1.2: What are the impacts of influencing factors' changes on the pricing strategy and profits of container shipping companies and NVOCC/freight forwarders? Effects of five influencing factors' changes on the pricing strategy and profits of the container shipping company and the NVOCC/freight forwarders are analyzed through numerical examples. The specific pricing strategy for the container shipping company is proposed under different variables assignment. On the one hand, it is verified that the impacts of opening the online direct channel on the container shipping company and the NVOCC/freight forwarder are dynamic. Container shipping companies may benefit or lose depending on various market situations and conditions. On the other hand, it is verified that the optimal online direct price should not be settled randomly. It differs when independent variables change. Container shipping companies should be cautious about the pricing strategy; otherwise, the container shipping company may suffer profit reduction or consumer losses.

5.2. Contribution

This is the first time that the dual-channel supply chain management is applied in CSI to analyze the impacts of online direct channel on the pricing strategy and profits of the container shipping company and the NVOCC/freight forwarder. The contribution can be summarized as follows:

(1) The dual-channel supply chain management CSI should successfully be applied with some modifications. A dual-channel supply chain in CSI with one container shipping company and one NVOCC/freight forwarder is constructed to be the research object. The optimization theory, non-cooperative game theory and consumer utility theory are applied synthetically for model construction in this study. After the model construction and optimization, a relevant decision-making framework for the container shipping company is established. The pricing strategy for the container shipping company in the dual-channel supply chain is proposed. Furthermore, the effects of independent variables on the pricing strategy and profits are also analyzed to propose more implications for the container shipping company.

(2) The research results and findings provide theoretical support for the analysis and understanding of the relationship between the container shipping company and the NVOCC/freight forwarder in the network environment.

(3) The established model and optimization decision could be a very useful reference to the pricing strategy for the container shipping company.

5.3. Limitations and further study areas

The present dissertation constructs a simplified and conceptual dual-channel supply chain in CSI, and profit models for the container shipping company and the NVOCC/freight forwarder are established with various assumptions. All the simplications, conceptual work and assumptions lead to the difference between the models in the dissertation and the complex reality in CSI. Therefore, limitations are inevitable because the models in the dissertation cannot reflect the reality perfectly. The limitations worth further research are listed in the following.

1. The limitations for the conceptual dual-channel supply chain in CSI in chapter 3

(1) Lack of reference to the third-party e-commerce platform in the dual-channel supply chain

For the online channel, only the online direct channel in which the container shipping company sells the container shipping service directly to cargo owners through their own online platform was discussed. However, the third-party e-commerce platform also exists in reality. The third-party e-commerce platform is not mentioned in the dissertation. The reason is that the e-commerce in CSI is at an emerging stage now. The online transaction volumes are low in both the container shipping company's own platform and third-party e-commerce platform. However, the third-party e-commerce platform should be considered for further studies with the development of e-commerce in CSI.

(2) Only one container shipping company and one NVOCC/freight forwarder are considered in the conceptual dual-channel supply chain.

Some container shipping companies have already opened the online direct channel, while most of the top 12 container liners adopt the attitude of watching for the online direct channel. The more realistic situation is that the NVOCC/freight forwarder is faced with two competitive container shipping companies, one of which has online direct and offline retail channels and the other one which has only an offline retail channel. What is more, the pricing strategy and profits for the container shipping company and the NVOCC/freight forwarder will be totally different in that situation. It will be more valuable to discuss that situation in the future study.

(3) Lack of study on centralized dual-channel supply chain

In the dissertation, only the decentralized dual-channel supply chain is discussed because there is no cooperation on online and offline pricing between the container shipping company and the NVOCC/freight forwarder at present. However, the cooperation between them is inevitable with the development of e-commerce in CSI. Therefore, it is more proactive to study what the pricing strategy is for the two parties in a centralized dual-channel supply chain, and what the optimal coordination contract is for them to improve the profits of the whole supply chain in CSI.

2. The limitations for models' construction and optimization in chapter 3

(1) Only part of influencing factors is selected as inputs of the models

Only some of the factors influencing the pricing strategy and profits in the dual-channel supply chain are selected as the inputs of models in CSI. The risk preferences of stakeholders in the dual-channel supply chain are not considered in this dissertation. It was just simply assumed that all the stakeholders are risk-neutral. Furthermore, the demand is assumed fixed in the dissertation in order to simplify the model construction and optimization. Obviously, it cannot reflect the reality in CSI. In conclusion, the previous two factors deserve more research in the future.

(2) Lack of the discussion on the situation that the wholesale price is decided by container shipping company

It is assumed that the wholesale price is given by the market and the container shipping company has no pricing power in the wholesale price in this dissertation. Though the whole CSI is regarded as an oligopoly market, the extent of oligopoly differs in different routes (Rau & Spinler, 2016; Sys, 2009). In some specific routes, it can be assumed that the container shipping company can set the wholesale price by himself. Therefore, it would be more inclusive to discuss the other situation when the wholesale price is decided by the container shipping company. In addition, the Stackelberg theory, not the Nash equilibrium theory is applied to study the pricing strategy in that situation.

(3) The assumption that container shipping company and NVOCC/freight forwarder both have full information about each other does not comply with the reality

The assumption has no compliance with the reality in CSI. The pricing strategy for the container shipping company and the NVOCC/freight forwarder is influenced by various factors. It is impossible for them to obtain the other parties' full information. For example, the effect of unit cost on the pricing strategy and profits was discussed in chapter 4.3.2. Normally, the unit cost is confidential information for the container shipping company. The NVOCC/freight forwarder cannot obtain the full information of that. It would be more realistic to change that assumption in further research.

3. The limitations for numerical examples in chapter 4

(1) The limitation of variable assignment

Real market data in CSI for variables assignment was referred to. However, the data is provided by an international container shipping company operating both main trucking routes and continental trade lines. The pricing strategy proposed by the dissertation may not applicable to regional carriers who only operate on intra-region trade service.

(2) Lack of sensitivity analysis of consumer purchase cost (b_r and b_d)

The effects of consumer online and offline purchase costs are not discussed as other inputs in the dissertation. It is difficult to obtain the real consumer purchase cost from the cargo owner as the basic scenario. That is the reason why a sensitivity analysis of consumer purchase cost (b_r and b_d) was not conducted. It would be more inclusive to supplement them in the future studies if we more detailed data of consumer purchase cost in CSI can be obtained.

(3) The limited interval of consumer preference for online direct channel

The consumer preference for the online direct channel is the relative preference to the offline retail channel. It is assumed that the consumer preference for the online direct channel changed from zero to one in the dissertation. When the consumer preference for the online direct channel equals one, it means cargo owners have the same preferences for both online direct and offline retail channels. It would be more realistic to discuss the situation that the consumer preference for the online direct channel becomes greater than one when CSI is deeply evolved in e-commerce.

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APPENDICES

Appendix 1: Programming content of numerical examples in chapter 4.2.1

The effects of online unit cost c_d and consumer preference for online direct channel θ on pricing strategy and profits

```
v=1560;
b_r=100;
b_d=80;
x=linspace(0.968,1,20);
c_r=1200;
c_d=linspace(1000,1270,20);
w=1400;
P_d=zeros(20,20);
P_r=zeros(20,20);
Q_r=zeros(20,20);
Q_d=zeros(20,20);
T_r=zeros(20,20);
T_m=zeros(20,20);
T=zeros(20,20);
for n=1:20
   for i=1:20     if(w<x(n)*v-b_d&&(1-x(n))*v+b_d<2*b_r&&b_d+b_r+c_d(i)-
c_r+(1-x(n))*v>=3/2*(v-w))
          P_d(n,i)=w+1./3.*(-b_d+2.*b_r+2.*c_d(i)-2.*c_r-(1-x(n)).*v);
          P_r(n,i)=w+1/3*(b_d+b_r+c_d(i)-c_r+(1-x(n))*v);
          Q_r(n,i)=(b_d+b_r+c_d(i)-c_r+(1-x(n))*v)/(3*b_r);
          Q_d(n,i)=(-b_d+2*b_r-c_d(i)+c_r-(1-x(n))*v)/(3*b_r);
T_r(n,i)=(b_d+b_r+c_d(i)-c_r+(1-x(n))*v)*(b_d+b_r+c_d(i)-c_r+(1-
x(n))*v)/(6*b_r);         T_m(n,i)=(b_d*b_d+4*b_r*b_r+b_r*(-4*v+9*w+4*v*x(n)-
```

```
4*c_d(i)-5*c_r)+(v-v*x(n)+c_d(i)-c_r)*(v-v*x(n)+c_d(i)-c_r)-2*b_d*(-
v+v*x(n)+2*b_r-c_d(i)+c_r))/(9*b_r);
      T(n,i)=T_r(n,i)+T_m(n,i);
        else if(w<x(n)*v-b_d&&(1-x(n))*v+b_d<2*b_r&&b_d+b_r+c_d(i)-
c_r+(1-x(n))*v<3/2*(v-w))
            P_d(n,i)=x(n)*v-b_d;
            P_r(n,i)=(v+w)/2;
            Q_r(n,i)=(v-w)/(2*b_r);
            Q_d(n,i)=(2*b_r-v+w)/(2*b_r);
            T_r(n,i)=(v-w)*(v-w)/(4*b_r);
      T_m(n,i)=((2*b_r-v+w)*(x(n)*v-b_d-c_d(i))+(v-w)*(w-c_r))/(2*b_r);
            T(n,i)=T_r(n,i)+T_m(n,i);
          else if(w<x(n)*v-b_d&&(1-x(n))*v+b_d>=2*b_r)
              P_d(n,i)=w;
              P_r(n,i)=(1-x(n))*v+b_d-b_r+w;
              Q_r(n,i)=1;
              T_r(n,i)=(1-x(n))*v+b_d-b_r;
              T_m(n,i)=w-c_r;
              T(n,i)=T_r(n,i)+T_m(n,i);
        end
      end
    end
  end
end
```

Appendix 2: Programming content of numerical examples in chapter 4.2.2

The effects of online unit cost c_d on pricing strategy and profits where $\theta = 0.98$

```
v=1560;
b_r=100;
b_d=80;
x=0.98;
c_r=1200;
c_d=[1000:9:1270];
w=1400;
P_d=zeros(1,31);
P_r=zeros(1, 31);
Q_r=zeros(1, 31);
Q_d=zeros(1, 31);
T_r=zeros(1, 31);
T_m=zeros(1, 31);
T=zeros(1, 31);
for n=1:31
   if(w<x*v-b_d&&(1-x)*v+b_d<2*b_r&&b_d+b_r+c_d(n)-c_r+(1-x)*v>=3/2*(v-
w))
            P_d(n)=w+1./3.*(-b_d+2.*b_r+2.*c_d(n)-2.*c_r-(1-x).*v);
            P_r(n)=w+1/3*(b_d+b_r+c_d(n)-c_r+(1-x)*v);
            Q_r(n)=(b_d+b_r+c_d(n)-c_r+(1-x)*v)/(3*b_r);
            Q_d(n)=(-b_d+2*b_r-c_d(n)+c_r-(1-x)*v)/(3*b_r);
            T_r(n)=(b_d+b_r+c_d(n)-c_r+(1-x).*v).*(b_d+b_r+c_d(n)-c_r+(1-
x).*v)./(6.*b_r);
            T_m(n)=(b_d*b_d+4*b_r*b_r+b_r*(-4*v+9*w+4*v*x-4*c_d(n)-
5*c_r)+(v-v*x+c_d(n)-c_r)*(v-v*x+c_d(n)-c_r)-2*b_d*(-v+v*x+2*b_r-
c_d(n)+c_r))/(9*b_r);
            T(n)=T_r(n)+T_m(n);
```

```
          else if(w<x*v-b_d&&(1-x)*v+b_d<2*b_r&&b_d+b_r+c_d(n)-c_r+(1-
x)*v<3/2*(v-w))
                P_d(n)=x*v-b_d;
                P_r(n)=(v+w)/2;
                Q_r(n)=(v-w)/(2*b_r);
                Q_d(n)=(2*b_r-v+w)/(2*b_r);
                T_r(n)=(v-w)*(v-w)/(4*b_r);
                T_m(n)=((2*b_r-v+w)*(x*v-b_d-c_d(n))+(v-w)*(w-c_r))/(2*b_r);
                T(n)=T_r(n)+T_m(n);
             else if(w<x*v-b_d&&(1-x)*v+b_d>=2*b_r)
                 P_d(n)=w;
                 P_r(n)=(1-x)*v+b_d-b_r+w;
                 Q_r(n)=1;
                 T_r(n)=(1-x)*v+b_d-b_r;
                 T_m(n)=w-c_r;
                 T(n)=T_r(n)+T_m(n);
           end
       end
   end
end
```

Appendix 3: Programming content of numerical examples in chapter 4.3.1

The effects of consumers' valuation of container shipping service v on pricing strategy and profits

```
v=[1500:5:1600]
b_r=100;
b_d=80;
x=1;
c_r=1200;
c_d=1200;
w=1400;
P_d=zeros(1,21);
P_r=zeros(1, 21);
Q_r=zeros(1, 21);
Q_d=zeros(1, 21);
T_r=zeros(1, 21);
T_m=zeros(1, 21);
T=zeros(1, 21);
for n=1:21 if(w<x*v(n)-b_d&&(1-x)*v(n)+b_d<2*b_r&&b_d+b_r+c_d-c_r+(1-
x)*v(n)>=3/2*(v(n)-w))
        P_d(n)=w+1./3.*(-b_d+2.*b_r+2.*c_d-2.*c_r-(1-x).*v(n));
        P_r(n)=w+1/3*(b_d+b_r+c_d-c_r+(1-x)*v(n));
        Q_r(n)=(b_d+b_r+c_d-c_r+(1-x)*v(n))/(3*b_r);
        Q_d(n)=(-b_d+2*b_r-c_d+c_r-(1-x)*v(n))/(3*b_r);
T_r(n)=(b_d+b_r+c_d-c_r+(1-x).*v(n)).*(b_d+b_r+c_d-c_r+(1-x).*v(n))./(6.*b_r);
T_m(n)=(b_d*b_d+4*b_r*b_r+b_r*(-4*v(n)+9*w+4*v(n)*x-4*c_d-5*c_r)+(v(n)-
v(n)*x+c_d-c_r)*(v(n)-v(n)*x+c_d-c_r)-2*b_d*(-v(n)+v(n)*x+2*b_r-
c_d+c_r))/(9*b_r);
        T(n)=T_r(n)+T_m(n);
```

```
        else if(w<x*v(n)-b_d&&(1-x)*v(n)+b_d<2*b_r&&b_d+b_r+c_d-c_r+(1-
x)*v(n)<3/2*(v(n)-w))
            P_d(n)=x*v(n)-b_d;
            P_r(n)=(v(n)+w)/2;
            Q_r(n)=(v(n)-w)/(2*b_r);
            Q_d(n)=(2*b_r-v(n)+w)/(2*b_r);
            T_r(n)=(v(n)-w)*(v(n)-w)/(4*b_r);           T_m(n)=((2*b_r-
v(n)+w)*(x*v(n)-b_d-c_d)+(v(n)-w)*(w-c_r))/(2*b_r);
            T(n)=T_r(n)+T_m(n);
          else if(w<x*v(n)-b_d&&(1-x)*v(n)+b_d>=2*b_r)
              P_d(n)=w;
              P_r(n)=(1-x)*v(n)+b_d-b_r+w;
              Q_r(n)=1;
              T_r(n)=(1-x)*v(n)+b_d-b_r;
              T_m(n)=w-c_r;
              T(n)=T_r(n)+T_m(n);
        end
      end
   end
end
```

Appendix 4: Programming content of numerical examples in chapter 4.3.1

The effects of consumers' valuation of container shipping service v and wholesale price w on pricing strategy and profits

```
v=[1500:15:1800]
b_r=100;
b_d=80;
%x=[0.968:0.002:1];
x=1;
c_r=1200;
c_d=1200;
%c_d=[800:30:1400];
P_d=zeros(1,21);
P_r=zeros(1, 21);
Q_r=zeros(1, 21);
Q_d=zeros(1, 21);
T_r=zeros(1, 21);
T_m=zeros(1, 21);
T=zeros(1, 21);
for n=1:21 if(14/15.6*v(n)<x*v(n)-b_d&&(1-x)*v(n)+b_d<2*b_r&&b_d+b_r+c_d-
c_r+(1-x)*v(n)>=3/2*(v(n)-14/15.6*v(n)))
        P_d(n)=14/15.6*v(n)+1./3.*(-b_d+2.*b_r+2.*c_d-2.*c_r-(1-x).*v(n));
          P_r(n)=14/15.6*v(n)+1/3*(b_d+b_r+c_d-c_r+(1-x)*v(n));
          Q_r(n)=(b_d+b_r+c_d-c_r+(1-x)*v(n))/(3*b_r);
          Q_d(n)=(-b_d+2*b_r-c_d+c_r-(1-x)*v(n))/(3*b_r);
T_r(n)=(b_d+b_r+c_d-c_r+(1-x).*v(n)).*(b_d+b_r+c_d-c_r+(1-x).*v(n))./(6.*b_r);
T_m(n)=(b_d*b_d+4*b_r*b_r+b_r*(-4*v(n)+9*14/15.6*v(n)+4*v(n)*x-4*c_d-
5*c_r)+(v(n)-v(n)*x+c_d-c_r)*(v(n)-v(n)*x+c_d-c_r)-2*b_d*(-v(n)+v(n)*x+2*b_r-
c_d+c_r))/(9*b_r);
```

```
            T(n)=T_r(n)+T_m(n);
         else if(14/15.6*v(n)<x*v(n)-b_d&&(1-x)*v(n)+b_d<2*b_r&&b_d+b_r+c_d-
c_r+(1-x)*v(n)<3/2*(v(n)-14/15.6*v(n)))
               P_d(n)=x*v(n)-b_d;
               P_r(n)=(v(n)+14/15.6*v(n))/2;
               Q_r(n)=(v(n)-14/15.6*v(n))/(2*b_r);
               Q_d(n)=(2*b_r-v(n)+14/15.6*v(n))/(2*b_r);
               T_r(n)=(v(n)-14/15.6*v(n))*(v(n)-14/15.6*v(n))/(4*b_r);
T_m(n)=((2*b_r-v(n)+14/15.6*v(n))*(x*v(n)-b_d-c_d)+(v(n)-
14/15.6*v(n))*(14/15.6*v(n)-c_r))/(2*b_r);
               T(n)=T_r(n)+T_m(n);
            else if(14/15.6*v(n)<x*v(n)-b_d&&(1-x)*v(n)+b_d>=2*b_r)
                 P_d(n)=14/15.6*v(n);
                 P_r(n)=(1-x)*v(n)+b_d-b_r+14/15.6*v(n);
                 Q_r(n)=1;
                 T_r(n)=(1-x)*v(n)+b_d-b_r;
                 T_m(n)=14/15.6*v(n)-c_r;
                 T(n)=T_r(n)+T_m(n);
          end
       end
    end
end
```

Appendix 5: Programming content of numerical examples in chapter 4.3.2

The effects of unit cost c_r on pricing strategy and profits

```
v=1560;
b_r=100;
b_d=80;
x=1;
c_r=[1000:15:1300]
w=1400;
P_d=zeros(1,21);
P_r=zeros(1, 21);
Q_r=zeros(1, 21);
Q_d=zeros(1, 21);
T_r=zeros(1, 21);
T_m=zeros(1, 21);
T=zeros(1, 21);
for n=1:21
if(w<x*v-b_d&&(1-x)*v+b_d<2*b_r&&b_d+b_r+c_r(n)-c_r(n)+(1-x)*v>=3/2*(v-
w))
        P_d(n)=w+1./3.*(-b_d+2.*b_r+2.*c_r(n)-2.*c_r(n)-(1-x).*v);
        P_r(n)=w+1/3*(b_d+b_r+c_r(n)-c_r(n)+(1-x)*v);
        Q_r(n)=(b_d+b_r+c_r(n)-c_r(n)+(1-x)*v)/(3*b_r);
        Q_d(n)=(-b_d+2*b_r-c_r(n)+c_r(n)-(1-x)*v)/(3*b_r);
T_r(n)=(b_d+b_r+c_r(n)-c_r(n)+(1-x).*v).*(b_d+b_r+c_r(n)-c_r(n)+(1-
x).*v)./(6.*b_r);
        T_m(n)=(b_d*b_d+4*b_r*b_r+b_r*(-4*v+9*w+4*v*x-4*c_r(n)-
5*c_r(n))+(v-v*x+c_r(n)-c_r(n))*(v-v*x+c_r(n)-c_r(n))-2*b_d*(-v+v*x+2*b_r-
c_r(n)+c_r(n)))/(9*b_r);
        T(n)=T_r(n)+T_m(n);
```

```
        else if(w<x*v-b_d&&(1-x)*v+b_d<2*b_r&&b_d+b_r+c_r(n)-c_r(n)+(1-
x)*v<3/2*(v-w))
            P_d(n)=x*v-b_d;
            P_r(n)=(v+w)/2;
            Q_r(n)=(v-w)/(2*b_r);
            Q_d(n)=(2*b_r-v+w)/(2*b_r);
            T_r(n)=(v-w)*(v-w)/(4*b_r);
      T_m(n)=((2*b_r-v+w)*(x*v-b_d-c_r(n))+(v-w)*(w-c_r(n)))/(2*b_r);
            T(n)=T_r(n)+T_m(n);
          else if(w<x*v-b_d&&(1-x)*v+b_d>=2*b_r)
              P_d(n)=w;
              P_r(n)=(1-x)*v+b_d-b_r+w;
              Q_r(n)=1;
              T_r(n)=(1-x)*v+b_d-b_r;
              T_m(n)=w-c_r(n);
              T(n)=T_r(n)+T_m(n);
        end
    end
  end
end
```

Appendix 6: Programming content of numerical examples in chapter 4.3.2

The effects of unit cost c_r and wholesale price w on pricing strategy and profits

```
v=1560;
b_r=100;
b_d=80;
x=1;
c_r=[1180:4:1260]
P_d=zeros(1,21);
P_r=zeros(1, 21);
Q_r=zeros(1, 21);
Q_d=zeros(1, 21);
T_r=zeros(1, 21);
T_m=zeros(1, 21);
T=zeros(1, 21);
for n=1:21
if(14/12*c_r(n)<x*v-b_d&&(1-x)*v+b_d<2*b_r&&b_d+b_r+c_r(n)-c_r(n)+(1-
x)*v>=3/2*(v-14/12*c_r(n)))
        P_d(n)=14/12*c_r(n)+1./3.*(-b_d+2.*b_r+2.*c_r(n)-2.*c_r(n)-(1-x).*v);
             P_r(n)=14/12*c_r(n)+1/3*(b_d+b_r+c_r(n)-c_r(n)+(1-x)*v);
             Q_r(n)=(b_d+b_r+c_r(n)-c_r(n)+(1-x)*v)/(3*b_r);
             Q_d(n)=(-b_d+2*b_r-c_r(n)+c_r(n)-(1-x)*v)/(3*b_r);
T_r(n)=(b_d+b_r+c_r(n)-c_r(n)+(1-x).*v).*(b_d+b_r+c_r(n)-c_r(n)+(1-
x).*v)./(6.*b_r);
             T_m(n)=(b_d*b_d+4*b_r*b_r+b_r*(-4*v+9*14/12*c_r(n)+4*v*x-
4*c_r(n)-5*c_r(n))+(v-v*x+c_r(n)-c_r(n))*(v-v*x+c_r(n)-c_r(n))-2*b_d*(-
v+v*x+2*b_r-c_r(n)+c_r(n)))/(9*b_r);
             T(n)=T_r(n)+T_m(n);
         else if(14/12*c_r(n)<x*v-b_d&&(1-x)*v+b_d<2*b_r&&b_d+b_r+c_r(n)-
c_r(n)+(1-x)*v<3/2*(v-14/12*c_r(n)))
```

```
                P_d(n)=x*v-b_d;
                P_r(n)=(v+14/12*c_r(n))/2;
                Q_r(n)=(v-14/12*c_r(n))/(2*b_r);
                Q_d(n)=(2*b_r-v+14/12*c_r(n))/(2*b_r);
                T_r(n)=(v-14/12*c_r(n))*(v-14/12*c_r(n))/(4*b_r);
T_m(n)=((2*b_r-v+14/12*c_r(n))*(x*v-b_d-c_r(n))+(v-
14/12*c_r(n))*(14/12*c_r(n)-c_r(n)))/(2*b_r);
                T(n)=T_r(n)+T_m(n);
             else if(14/12*c_r(n)<x*v-b_d&&(1-x)*v+b_d>=2*b_r)
                   P_d(n)=14/12*c_r(n);
                   P_r(n)=(1-x)*v+b_d-b_r+14/12*c_r(n);
                   Q_r(n)=1;
                   T_r(n)=(1-x)*v+b_d-b_r;
                   T_m(n)=14/12*c_r(n)-c_r(n);
                   T(n)=T_r(n)+T_m(n);
          end
      end
   end
end
```