Chapter 1

Dual-channel Supply Chains and Risk-averse Behaviors

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1.1 Introduction

Over the last decade, E-commerce has grown significantly and become an indispensable business framework in the global retail industry. According to Statista (www.statista.com), the e-retail sales worldwide were 1,548 billion US$ in 2015 and reached 3,535 billion US$ in 2019. In terms of the share of the global retail sales, E-commerce accounted for 7.4% in 2015 and reached 14.1% in 2019. It was estimated that about 1.92 billion people purchased goods or services online in 2019 [Clement, 2020]. Specifically, the retail E-commerce sales worldwide in billion US$ and its share of total retail sales from 2015 to 2019 are shown in Table 1.1 (based on Clement, [2020]).

Table 1.1. Retail E-commerce sales and share worldwide from 2015 to 2019

Year	2015	2016	2017	2018	2019
Sales in US$ billion	1548	1845	2382	2982	3535
Share of total retail	7.4%	8.6%	10.4%	12.2%	14.1%

The outbreak of the COVID-19 pandemic has reshaped our daily life. More consumers tend to do shopping online in greater quantity and frequency. According to the report from IBM's US Retail Index, the department stores are expected to decline by over 60%, whereas E-commerce is estimated to grow by nearly 20% in 2020 [Perez, 2020].

With the rapid development of E-commerce and information communication technology, online direct sales channels have become an important marketing channel strategy for manufacturers. Many brand manufacturers, e.g. IBM, HP, Lenovo, Unilever, Heinz, Nike, Pepsi Co and Nestle, have been involved in E-commerce. In fact, there have been about 45% of manufacturers selling directly online [Redtechnology, 2020].

The benefits of adopting online sales channels are evident including increasing revenue, reducing costs, expanding reach, influencing the end users, deepening customer relationships, and gathering insight for product development. However, the direct sales channels also bring about many challenging issues on relationship management along supply chains. In particular, there is a common concern that creating a direct-to-consumer online channel will lead to competitions and conflicts with existing physical offline marketing channel. This phenomenon is sometimes called manufacturer encroachment. Specifically, manufacturer encroachment refers to a practice where the manufacturer in a supply chain introduces a direct channel and competes with the retailer in the traditional wholesale market. A dual-channel supply chain may be defined as a supply chain system consisting of a traditional offline retail channel (i.e. brick-and-mortar channel) and a direct online channel. This book aims to address how to manage and coordinate the decisions of players in such dual-channel supply chain contexts.

Since the dual-channel supply chain is closely related to marketing channel theory and supply chain management, Section 1.2 will describe the marketing channel theory and supply chain management and their relevance to dual-channel supply chain systems. Section 1.3 explains the concepts of uncertainty, risk and risk attitude, which leads to an important phenomenon of decision makers in supply chain systems, i.e. the risk-averse behaviors. Three most commonly used types of risk assessment techniques including mean-variance, value-at-risk, and conditional-value-at-risk will be explained and contrasted in terms of their relative

advantages. Section 1.4 describes typical decision-making problems in dual-channel supply chain systems. Finally, the structure of the book is presented in Section 1.5.

1.2 Marketing Channel and Supply Chain Management

This section introduces the relevant concepts in the marketing channel theory first, and then introduces the concept of supply chain management with the discussions of their relevance to the dual-channel supply chain management.

1.2.1 *Marketing channel and relevance to dual-channel supply chains*

Marketing Channel can be defined as "*the external contactual organization that management operates to achieve its distribution objectives*" [Rosenbloom, 2004]. Kotler and Keller [2015] indicated that marketing channels are sets of interdependent organizations involved in the process of making a product or service available for use or consumption. From the above definitions, marketing channel emphasizes the contacts with external organizations. Such contacts are mainly associated with negotiatory functions, e.g. buying, selling, transferring title to goods or services. The distribution objectives of marketing channel are to make a product or service available to customer for use or consumption in an efficient and effective manner.

The basic role of marketing channel is to bridge the gap between the producer of a product and its users. Marketing channel strategies involve the design and management of channel structure. From the managerial perspective, channel structure can be defined as the group of channel members to which a set of distribution tasks has been allocated. In consumer markets, there are a range of channel structures, e.g. direct channel, multi-level indirect structure. The most common channel structure for consumer products is four-level indirect channel from manufacturer to wholesaler, retailer, and consumers. After a marketing channel has been established, a number of flows emerge among channel

members, e.g. product flow, negotiation flow, ownership flow, information flow, promotion flow, and payment flow. More specifically, product flow refers to the actual physical movement of goods from the manufacturer through all of the channel members who physically possess the goods, to final consumers. Negotiation flow refers to the interplay of the buying and selling functions between two channel members concerning the transfer of title to goods and the payment arrangement. Ownership flow refers to the movement of the title to the goods as it is passed along from the manufacturer to final consumers. Information flow refers to the documentations and communications that are exchanged among channel members associated with the negotiation, transaction and physical distribution. Information flow can move up or down among all relevant parties. Promotion flow refers to the flow of persuasive communication from upstream parties to downstream parties in the form of advertising, personal selling, sales promotion, and public relations. Payment flow refers to the fund transactions in the purchase and sale of goods or services, which is the reverse of ownership flow. Broadly speaking, marketing channel strategy involves planning and managing all of the above flows associated with the marketing channel [Rosenbloom, 2004].

In the context of marketing channel, there are three important types of channel behaviors that characterize the channel relationships: competition, conflict, and power. Competition is the behavior in which different parties are working for a goal or object controlled by another party, e.g. competing for customers in the same market. Channel competition occurs when organizations in different marketing channels compete with each other in the convention commercial sense. It is an inter-channel relationship. Conflict is a state of opposition or discord among the organizations comprising a marketing channel. Channel conflict occurs when one channel member perceives that another member's actions impede the attainment of its goals. Hence, channel conflict is an intra-channel relationship. There are seven common causes that lead to channel conflict: role incongruities, resource scarcities, differences of perception, differences of expectation, decision domain disagreements, incompatible goals, and communication difficulties [Rosenbloom, 2004]. In the dual-channel context, competition and conflict co-exist because the same two

channel members (e.g. manufacturer and retailer) may be located in the same marketing channel in a vertical relationship (traditional offline channel); meanwhile, they may also be located in different marketing channels in a horizontal relationship (offline channel versus online channel).

Channel power is defined as the capacity of one channel member to control or influence the behavior of another channel members, e.g. to get another channel member to do something that might not be done otherwise. There are five typical categories of channel power include reward power, coercive power, expert power, referent power, and legitimate power [Rosenbloom, 2004]. Channel conflict often arises because channel members have power relationships. For example, Dell had been selling HP printers for 8 years, which was often bundled with Dell's computers. When HP heard that Dell was considering selling its own line of Dell printers, HP employed coercive power by dropping Dell as a channel member from its marketing channel with the intention to dissuade Dell from implementing its plan [Rosenbloom, 2004]. In general, channel members will gain cooperation best if they cultivate the channel power in the order of referent power, expert power, legitimate power, and reward power, and avoid the use of coercive power that may escalate the channel conflict and even lead to the breakdown of the marking channel [Kotler and Keller, 2015]. In the dual-channel context, the appropriate use of channel powers may be able to coordinate channel relationships and mitigate the double marginalization phenomenon.

Marketing channel theory focuses on inter-organizational relationships with less attention to intra-organizational issues. Moreover, marketing channel has less emphasis on the contact with facilitators or facilitating intermediaries such as raw material suppliers, transport operators, freight forwarders, public warehouse companies, banks, insurance companies, etc. In that sense, the concept of supply chain expands the notion of marketing channel, which will be explained in next sub-section.

1.2.2 *Supply chain management and relevance to dual-channel supply chains*

According to Council of Supply Chain Management Professionals, supply chain management (SCM) can be defined as the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. Here the supply chain activities cover everything from product development, sourcing and production to logistics, and the information systems needed to coordinate these activities. It implies that multiple organizations are linked together to form partnerships as the supply chain through physical product flows and information flows [https://cscmp.org].

A few points can be extracted from the definition of SCM. Firstly, SCM encompasses the planning and management of all activities involved in product development, sourcing, procurement, operations, and logistics. Secondly, SCM can include all the relevant organizations such as suppliers, intermediaries, third-party service providers, and customers as channel partners. Thirdly, SCM emphasizes coordination, collaboration and integration internally within an organization and externally across various channel partners with the aim to maximize customer value in the most effective, efficient and sustainable way.

The differences between supply chains and marketing channels may be explained from the following aspects:

- *Activities*: Supply chain involves broader activities. It can span from raw materials, work-in-progress, finished goods, to reverse logistics. Marketing channels mainly focus on the product by bridging the gap between the producer and customers. Hence, marketing channels provide a narrower scope within the supply chain.
- *Entities*: Marketing channels usually involve manufacturer, wholesaler, retailer, and customers as channel members. Supply chain can involve a wider range of entities, not only including those in marketing channels, but also including third-party service providers, logistics agents, supplier's suppliers, and customer's customers.

- *Focal points*: marketing channel is purely customer-facing with the emphasis on the marketing mix, i.e. product, place, price, promotion. The marketing channel management attempts to address the questions like: does the product meet customers' needs? Will customers be able to find the product where they shop? Will customers consider that the product is priced favorably? Will the marketing communications be able to reach customers? On the other hand, SCM focuses on the flow and storage of raw materials, work-in-progress and finished goods along the supply chain by maximizing customer value in the most effective, efficient and sustainable way.
- *Relationships*: entities in marketing channel are often loosely linked on the basis of an arm's length transaction. Channel conflict and channel power are two important behaviors in marketing channels. SCM emphasizes on partnerships. Coordination and collaboration are essential relationships among supply chain members in order to achieve its goal. Supply chain contract can be an effective measure to resolve the channel conflict and channel competition issues arising from dual channel situations.

From the above discussion, it can be seen that it is more appropriate to discuss the decision-making in the dual-channel context from the supply chain management perspective. Therefore, this book will use the term dual-channel supply chain, which refers to a supply chain system consisting of a traditional retail channel and a direct online channel.

Supply chain systems face a variety of uncertainties that may exist in supply (e.g. material supply and subcontract order), production (e.g. processing time and resource availability), transport (e.g. delivery delay and equipment availability), demand (e.g. customer orders and demand arrivals), and environmental factors (e.g. market price, exchange rate fluctuation, politic events, natural disasters). Different decision-makers may perceive the impact of uncertainty differently. This leads to the concept of risk attitude, which in turn affects the supply chain members' decision behaviors. Such behavior is an emerging and important phenomenon that will be discussed in next section.

1.3 Risk-Averse Behavior in Dual-Channel Supply Chains

Uncertainty is defined as the state of being uncertain, usually applies to future events that cannot be predicted accurately. Uncertainty may be classified into two types: aleatory uncertainty (due to randomness) and epistemic uncertainty (due to lack of knowledge). Risk can be defined as the negative effect of uncertainty on objectives. It emphasizes on the undesirable outcome caused by the uncertainty.

Risk attitude refers to the decision maker's chosen response to the risk, which is influenced by its perception on the consequence of the uncertainty. Risk attitudes exist on a spectrum covering risk paranoid, risk averse, risk neutral, risk seeking, and risk addicted. Nevertheless, the terminologies of risk averse (risk avoiding), risk neutral and risk seeking (risk loving) are the most commonly used risk attitudes in practice.

In economics and finance fields, risk aversion is an attitude that an investor prefers lower returns with more certainty (i.e. lower risk). Risk seeking is an attitude that an investor prefers higher returns with less certainty (i.e. higher risk). Risk neutral is the middle attitude that an investor has an indifferent preference toward risk. In practice, most investors are regarded as risk averse.

In the last decade, risk attitude, especially risk averse behavior, has attracted much attention in supply chain management. The main reason is that supply chain operations are facing a substantial level of risks that may be caused by various uncertainties existed in the supply chain system and its environment. Note that the same uncertain situation may lead to different risk attitudes from decision makers depending on how they perceive the risk implied by the uncertainty. This drives different behaviors and then affects the decisions. Therefore, it is important to consider the risk attitudes of decision makers in the supply chain systems.

There are three common types of methods to measure a decision-maker’s risk attitude: mean-variance model [Chiu and Choi, 2016], value at risk [Tapiero 2005], and conditional value at risk [Li et al. 2014]. Each type of the risk measures has its own characteristics, which will be briefly introduced in the following sub-sections.

1.3.1 *Mean-variance method*

Mean-variance is the first analysis method proposed to estimate risk attitude [Markowitz, 1959]. The idea of the mean-variance method is to consider both the expected payoff (i.e. mean) and the variation of payoff (i.e. variance). The variance of the payoff represents the risk associated with the investment decision making problem. Intuitively, the variance of payoff reflects the level of uncertainty. A risk-averse investor would avoid the high variance of the payoff.

Mathematically, let π denote the profit of the decision maker. Under the mean-variance criterion, the utility function can be defined as:

$$U = \mathrm{E}(\pi) - \lambda \cdot \mathrm{V}(\pi) \tag{1.1}$$

Where E(.) represents the mathematical expectation, V(.) is the variance of the profit, and λ is a parameter representing the risk attitude. Positive λ represents risk-averse, negative λ represents risk seeking, and $\lambda=0$ indicates risk neutral attitude. Intuitively, a risk-averse decision maker would like to maximize the expected profit and minimize the variance of the profit at the same time. A variant of the mean-variance method is the mean-standard deviation method, which uses standard deviation instead of variance to represent the risk. The utility function under the mean-standard deviation criterion is given as follows, where SD(.) represents the standard deviation,

$$U = \mathrm{E}(\pi) - \lambda \cdot \mathrm{SD}(\pi) \tag{1.2}$$

The advantage of the mean-variance method is that it can be interpreted intuitively and is often analytically tractable. However, the mean-variance is a symmetric measure that treats desirable outcomes as the same as undesirable outcomes in the risk measure. As a result, it is not suitable for the cases where decision makers are more concerned with undesirable outcomes, e.g. losses [Zheng et al., 2017].

1.3.2 *Value-at-risk (VaR) method*

Value-at-risk (VaR) can be defined as the maximum amount of money that is expected to be lost at a pre-defined confidence level. From the profit perspective, VaR refers to the threshold value of the profit that the probability of the profit falling below the threshold value does not exceed a pre-specified level [Sarykalin et al., 2008].

Suppose profit π is a random variable. Let $v^{\eta}(\pi)$ be the η-quantile of the profit π, i.e. $\text{Prob}\{\pi \leq v^{\eta}(\pi)\} = \eta$. Namely, $v^{\eta}(\pi)$ represents the threshold value of the profit such that the probability of the profit falls below this threshold value would not exceed η. Let $F_{\pi}(.)$ denote the cumulative distribution function of profit π. The value at risk (VaR) is then given by,

$$\text{VaR}^{\eta}(\pi) := v^{\eta}(\pi) = \max\{z \mid F_{\pi}(z) \leq \eta\} \tag{1.3}$$

Statistically, $(1\text{-}\eta)$ represents the confidence level that profit π is greater than $v^{\eta}(\pi)$. In that sense, the VaR criterion allows decision makers to limit the likelihood of the resulting profits (or losses), which represents the decision makers' risk attitudes.

Specifically, the parameter η can be interpreted as a risk-averse indicator when taking a value in the interval (0, 1]. When η=1, the decision maker is risk neutral; otherwise it is risk averse. As the parameter η decreases towards 0, the decision maker becomes more risk-averse, i.e. tends to prefer a higher confidence level to generate at least a specific amount of profit.

1.3.3 *Conditional-value-at-risk (CVaR) method*

Note that VaR has a limitation that the tail end of the distribution of profit (or loss) is not assessed. Therefore, when the profits (or losses) are incurred at the tail end are substantially large or small, such volume is not properly measured. Conditional Value at Risk (CVaR) was created as an extension of VaR to overcome this shortcoming.

Mathematically, the CVaR can be defined as [Rockafellar and Uryasev, 2000, 2002; Sarykalin et al. 2008],

$$\mathrm{CVaR}^{\eta}(\pi) = \int_{-\infty}^{+\infty} z dF_{\pi}^{\eta}(z) \tag{1.4}$$

Where $F_{\pi}^{\eta}(z) = 1$, if $z \geq \mathrm{VaR}^{\eta}(\pi)$; $F_{\pi}^{\eta}(z) = F_{\pi}(z)/\eta$, if $z < \mathrm{VaR}^{\eta}(\pi)$. In the context of the objective function being profit, the profits less than VaR should be accounted for. Suppose the random variable π has a continuous probability distribution function, $\mathrm{CVaR}^{\eta}(\pi)$ can be interpreted as the conditional expectation of π subject to $\pi < \mathrm{VaR}^{\eta}(\pi)$. Therefore, CVaR is actually derived by taking a weighted average between the value at risk and profits less than the value at risk [Zheng et al., 2017].

An equivalent and more convenient definition of CVaR for a profit function π is given as follows [Rockafellar and Uryasev, 2000],

$$CVaR^{\eta}(\pi) = \max_{v \in R} \left\{ v + \frac{1}{\eta} E\left[\min(\pi - v, 0)\right] \right\} \tag{1.5}$$

The crucial feature of the above definition is that the function defined within the curly bracket in (1.5) is concave and continuously differentiable. This is especially useful to analyze the maximization problem, and to calculate the $\mathrm{CVaR}^{\eta}(\pi)$, because $\mathrm{CVaR}^{\eta}(\pi)$ defined in (1.5) can be calculated without first having to calculate the $\mathrm{VaR}^{\eta}(\pi)$, which would be more complicated.

1.3.4 *Comparisons of the three risk measure methods*

The mean-variance method is more intuitive and easier to analyze than the VaR and CVaR methods. However, the mean-variance is a symmetric measure and uses the same weight for desirable outcomes and undesirable outcomes, which may not capture the decision maker's risk attitude appropriately.

The VaR and CVaR are more suitable for the situations where decision makers are more concerned with undesirable outcomes. The VaR allows the decision makers to set a confidence level η, and the VaR can be defined as a threshold value such that the probability that the profit falls below this threshold value is η. The disadvantages of VaR include: the tail end of the distribution of objective function is not assessed, and it suffers from being unstable and difficult to work with numerically when losses are not

"normally" distributed [Rockafellar and Uryasev, 2002]. The CVaR is an extension of VaR that can overcome the shortcoming of VaR. It measures the average profit falling below the η-quantile level, and ignores the contribution of profit above the specified quantile [Rockafellar and Uryasev, 2000]. In addition, the CVaR is analytically tractable. However, the disadvantage of CVaR is its complex form and its physical meaning is not easy to understand and interpret by practitioners.

In this book, most of the chapters will use conditional-value-at-risk to measure agents' risk averse behavior to optimize the decisions in dual channel supply chains. Nevertheless, a couple of chapters will also apply the mean-variance or value-at-risk method.

1.4 Typical Decision-Making Problems in Dual-Channel Supply Chains

Balasubramanian [1998] was among the first to model the competition in the dual-channel or multiple-channel supply chains environment, in which direct channels (catalog and Internet marketers) and the conventional retail stores coexist [Li, 2018]. Since then, the research on dual channels has been increasing rapidly.

Existing research on dual-channel supply chains may be classified into the following categories according to the setting and scope of the decisions in the supply chain,

- *Channel conflict and channel selection*: When a supplier engages in online sales, it will affect the relationships with its reseller partners in the traditional retail channel. This leads to channel conflict and competition. The relevant issues include whether or not opt to sell online, whether or not to open an online channel by supplier itself or via retailer, which type of channel structure to select, and how to adjust the supplier-reseller relationships [Tsay and Agrawal, 2004; Chen et al., 2007; Cai, 2010; Hsiao and Chen, 2013].
- *Pricing strategies*: in a dual channel supply chain context, the manufacturer will not only make the wholesale pricing decision in the traditional retail channel but also the online

selling price in the online channel. The retailer is to make the retail price in the traditional physical channel. However, it is possible that a consistent pricing strategy (or equal-pricing strategy) is adopted in which the product selling prices are kept the same in both channels in order to mitigate the channel conflict. Determine the pricing decisions in dual channel supply chains under various scenarios has been the predominate research topic. Moreover, inconsistent pricing strategies have also attracted attention in dual-channel supply chains [Cattani et al., 2006; Li et al., 2014].

- *Risk-averse behavior*: when facing uncertainties, decision makers often take risk averse behavior attempting to lower the impact of the uncertainty. This phenomenon is very common in economics and finance. It has attracted much attention in supply chain management [Li et al., 2014; Li et al., 2016; Liu et al, 2016].
- *Coordination and contract design*: channel coordination and contract design are an important research topic in dual channel supply chains. The main purpose is to resolve the channel competition and channel conflict, and improve the overall supply chain performance. By appropriately designing a contract between the supplier and the retailer, it is possible that the decentralized dual channel supply chain can achieve the same overall performance as the centralized supply chain and both channel members could reach a win-win outcome [Cao, 2014; David and Adida, 2015; Li et al. 2016].
- *Environmental impact and green investment*: with the increasing concern on sustainable development, governments are imposing more strict carbon emission regulations. Business organizations have to consider environmental impacts of their products and commit more investment on green product development in the dual channel supply chain management [Carrillo et al., 2014; Xu et al., 2018].
- *Asymmetric information*: asymmetric information refers to the situations where channel members have different levels of information, e.g. market size, consumer preference,

production cost, and product attributes. It is possible that one channel member may deliberately hide or distort the information so that he can gain more profit in the supply chain. The existence of information asymmetry obviously affects the decision making in dual-channel supply chains [Cao et al., 2013; Lei et al. 2014; Li et al., 2017; Huang et al., 2018b]

- *Service strategies and impact*: in the dual channel context, additional services could be provided to add values, e.g. returns policy, trade-in policy, free shipping, and showroom services. Such services may affect the consumers' behaviors and channel members' other decisions [Chen and Bell, 2012; Jiang et al. 2017; Feng et al. 2019; Li et al. 2019].
- *Financing strategies and impact*: channel members may be constrained by capital to sustain the business operations. Arranging the cash flow along the supply chain or determining the optimal investment allocation among channel members would have a significant impact on channel strategies [Xia et al., 2017; Li et al. 2018; Salmani et al., 2018].
- *Cross-selling and free-riding*: in dual channel supply chains, when a consumer finds a product in one channel, but he may purchase it from the other channel. This can be caused by the inconsistent pricing strategy in two channels and will have an impact on channel members' decision making [Balakrishnan et al., 2014; He et al., 2016; Zhou et al., 2018].
- *Inventory management and demand fulfillment*: inventory management in dual channel supply chain is more complicated. Interesting issues includes what level of initial inventories to keep before the sales season, how to replenish inventories over multiple periods, and how to assign inventories to satisfy incoming demands from different channels [Chiang and Monahan, 2005; Takahashi et al., 2011; Fan et al., 2019].

It should be noted that the above topics are not exhaustive. Many new topics are emerging. They are not exclusive either, because some of the above topics are often tackled simultaneously, e.g. the decision making with risk-averse players and/or information asymmetry. This book will

cover most of the above decision-making problems in dual-channel supply chain systems with explicit consideration of risk averse behaviors of the decision makers.

1.5 Structure of The Book

This book consists of 10 chapters. Chapter 1 first introduces the relevant concepts in marketing channel theory and supply chain management, and explains their relevance to dual-channel supply chains. Secondly, we introduce the concepts of uncertainty, risk and risk attitude, which leads to an important phenomenon of decision makers in supply chain systems, i.e. the risk-averse behaviors. Three most commonly used types of risk assessment methods including mean-variance, value-at-risk, and conditional-value-at-risk are explained and contrasted in terms of their relative advantages. Thirdly, we categorize the existing literature on dual-channel supply chains into several groups according to the setting and scope of the decisions. Finally, the structure of the book is presented.

Chapter 2 examines the manufacturer's dual channel selection problem concerning whether to open an own online channel or use a retailer's online channel. Consumers' heterogeneity in the valuation of a product is assumed to be a uniform distribution. Stackelberg games are applied to obtain the optimal equilibrium solutions to two channel structures. The manufacturer's preference of the channel structures and its channel control abilities are analyzed and characterized analytically. The models are then extended to the cases with uncertain demand and risk-averse behavior, where the risk averse behavior is measured using the mean-variance method.

Chapter 3 considers the pricing decisions in a dual-channel supply chain with one risk-neutral supplier and one risk-averse retailer. The supplier provides one perishable product with price dependent stochastic demand. The Conditional Value-at-Risk (CVaR) criterion is used to measure the retailer's risk-averse behavior. A Nash bargaining model is presented to model the players' decisions such as the wholesale price, the retail price and the order quantity under equal bargaining power. With the assumption of a uniform distributed demand uncertainty, the Nash

bargaining equilibrium is obtained analytically. The supplier's profit share among the supply chain is then analyzed. The effects of the risk-averse indicator on the performance of two agents in various situations with varying channel powers, demand uncertainty and price sensitivities are illustrated.

Chapter 4 investigates the pricing decisions and channel coordination in a dual channel supply chain consisting of a risk-neutral supplier and a risk-averse retailer, in which the market demand is uncertain. Both members need determine an initial stock at the beginning of the sales season. The consistent pricing practice is assumed for the product selling prices in both channels. The retailer's risk averse behavior is measured using either the Value-at Risk (VaR) criterion or the Conditional Value-at-Risk (CVaR) criterion. Stackelberg game models are formulated, where the manufacturer is a leader in making decisions on initial inventory quantity and product selling price, and the retailer is a follower in making decisions on the order quantity. The equilibrium solutions are obtained in the decentralized and centralized situations. A new concept of channel coordination is defined. Based on that, an improved risk-sharing contract is designed to coordinate the dual-channel supply chain and ensure that both supply chain members achieve a win-win outcome.

Chapter 5 seeks optimal pricing and greening strategies in a dual-channel supply chain. The consistent pricing practice is assumed for the product selling prices in both channels. Stackelberg game models are formulated for both centralized and decentralized cases. Optimal pricing and greening level of products are obtained analytically. The channel choice problem is discussed by comparing the dual-channel supply chain with the single channel supply chain under the green strategy. The channel conflict and coordination are resolved by designing a two-part tariff contract between two agents. Finally, the extension of the model to the situations where the retailer takes risk-averse behavior in the dual-channel green supply chain is discussed.

Chapter 6 considers a dual-channel supply chain consisting of a risk-neutral manufacturer and a risk-averse retailer, where the manufacturer offers a consumer returns policy in the online channel. The market demand is uncertain and related to the refund-amount. The conditional value-at-risk (CVaR) criterion is used to measure the retailer's risk-averse behavior.

The impacts of customer returns policy and risk-averse behavior on the equilibrium solutions and supply chain agents' performance are analyzed. A buyback revenue-sharing contract is designed to coordinate the dual-channel supply chain, which essentially resolves the channel conflict problem. In addition, whether the returns policy can help improve the competitiveness of the online channel, and how the returns policy would affect the retailer's profit share among the supply chains are also discussed.

Chapter 7 studies the financing strategies in a supply chain where the retailer is capital-constrained and the supplier is risk-averse. The supplier makes wholesale pricing decisions and the retailer makes order quantity decisions facing uncertain demand. The supplier's risk-averse behavior is measured using the Conditional Value-at-Risk (CVaR) method under two financing strategies: partial credit guarantee (PCG) and trade credit financing (TCF). The optimal equilibrium solutions under PCG and TCF are obtained respectively, and the sensitivities of the solutions to some parameters are analyzed. It is shown that the preference of two financing strategies can be characterized by the switching curves in two-dimensional space of credit guarantee coefficient and risk aversion degree. There exists a region where TCF outperforms PCG for both players. In addition, the extension of the model to the dual-channel situations is discussed.

Chapter 8 examines the pricing and order quantity decisions in a dual-channel supply chain consisting of a risk-neutral manufacturer and a risk-averse retailer with asymmetric information on market size. The market demand information is uncertain, but the retailer has more information regarding the market size than the manufacturer. It is assumed that market demand size takes two types, high and low, and at each type the demand follows a truncated normal distribution. The mean-variance method is used to measure the retailer's risk-averse behavior. Stackelberg game models are developed for three scenarios: the benchmark scenario without the manufacturer's encroachment, the manufacturer's encroachment under symmetric information, and the manufacturer's encroachment under asymmetric information. It is found that whether the manufacturer and the retailer can be better off after manufacturer encroachment or information sharing depends on the manufacturer's per-unit selling cost and the retailer's risk averse level.

Chapter 9 considers the contracting and pricing decisions in a dual-channel supply chain consisting of a risk-neutral manufacturer and a risk-averse retailer with asymmetric information on production cost. The retailer's risk-averse behavior is measured using the Conditional Value-at-Risk (CVaR). To model the production cost information asymmetry, it is assumed that the manufacturer's production cost takes two types (a high type and a low type), which is privately known to the manufacturer. The retailer is assumed to be the principal and more powerful than the manufacturer. The retailer provides a menu of contracts to the manufacturer for selection. From the manufacturer's selection, the retailer can better estimate the production cost of the manufacturer and determine her retail price in the traditional channel. After than, the manufacturer sets the price for his online channel. Four situations are examined depending on the combinations of whether the manufacturer opens an online channel or not, and whether the manufacturer keeps his production cost information private or not.

Chapter 10 investigates the pricing decisions of two competing shipping companies (large and small) facing uncertain spot market demand considering risk-averse behavior and capacity constraint. This case can be regarded as two parallel channels competing for the same market. The larger shipping company is risk-neutral with sufficient capacity; while the smaller shipping company is risk-averse with limited shipping capacity. The conditional value at risk (CVaR) is used to measure the risk-averse attitude of the smaller supplier. A Nash game model is formulated to model two suppliers' pricing decisions and the equilibrium solution is obtained analytically. It is shown that the pricing decisions take two forms, which can be characterized by a threshold of the smaller supplier 2's capacity. With the assumption of uniformly distributed demand, it is found that as the smaller supplier becomes more risk-averse, both suppliers' optimal prices are decreasing, and the threshold value that determines the pricing strategy is also decreasing. The impacts of price sensitivity and competition intensity parameters on the optimal prices are also analyzed. Numerical experiments are performed to illustrate the analytical results and explore their validity in more general situations.

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