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Markdown Money Policies in Textiles and Clothing Supply Chains: A Multi-Methodological Study

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CERTIFICATE OF ORIGINALITY

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Abstract

Markdown Money Policy (MMP) is commonly adopted in the textiles and clothing (TC) supply chain when the supplier trades with his buyer. Under MMP, the downstream retail buyer pays a wholesale price to the upstream supplier in acquiring product supply and will receive a certain amount of "monetary sponsor" from the supplier for the needed inventory markdown at the end of the selling season.

In this thesis, a multi-methodological approach is adopted to study the adoption of MMP in TC supply chains. More specifically, empirical case studies, mathematical modeling, and behavioral experimental explorations are all employed with different purposes: The case studies help us gain a clearer picture about the current practices of MMP adoption in the TC industry. After obtaining the inspiration and motivation from case studies, both analytical modeling research and behavioral experiments are conducted to further investigate different important aspects of MMPs.

Two TC companies which are implementing MMP, one from the U.S.A. and one from China, are selected as the case study targets. Via semi-structured interviews and discussions with staff members of the companies, it is found that the cultural factors, such as power distance and collectivism/individualism, have strong influence on contract selection and supplier-retailer relationship in implementing MMP. In

addition, the results of case studies show that the TC supplier now is more risk-averse than before and the TC buyer tends to have the self-serving fairness concern in their decision making process.

Inspired by the case studies, a theoretical analysis on MMP in a TC supply chain with a risk-averse supplier is analytically examined. Formulating the problem as a Stackelberg game in which the supplier is the leader, the analytical closed-form conditions for achieving channel coordination via MMP are derived. In addition, with real industrial data collected from two companies, extensive numerical analysis is conducted to examine the performance of the optimal MMP proposed. Important insights, including the significance of profit's coefficient of variation as a performance indicator in the supply chain, are developed. Managerial implications are discussed.

Finally, as revealed by the case studies that retail buyers possess self-serving fairness concerns on supply chain performance, a controlled laboratory experiment is conducted. In the experiment, each buyer's self-serving fairness concern is measured by a parameter called the *minimum profit share ratio* (MPSR), which is defined as the ratio of the buyer's profit to the whole supply chain profit. To be specific, a two-echelon supply chain is considered, in which a supplier offers a take-it-or-leave-it MMP to a buyer who has an MPSR concern. In laboratory experiments, the role of the supplier is played by human subjects who are practitioners in the TC industry. To ensure that the MPSR concept is fully implemented, the role of the buyer is played by the computer. Mirroring the observed industrial practice, the markdown price is defined as a fixed percentage of the wholesale price, and the supplier needs to decide on the value of wholesale price. The empirical results show that the average wholesale price decreases as the MPSR increases. Moreover, when the MPSR increases, the supplier's average profit decreases, whereas that of the buyer increases. As for the whole supply chain, our experiments suggest there is an inverse U-shaped relationship between the supply chain profit and the MPSR; thus the presence of an MPSR concern leads to a higher supply chain risk in profit uncertainty. The empirical result implies that when the buyer tends to split the supply chain profit equally with the supplier (MPSR=0.5; in this case, neither party faces disadvantageous inequality), the whole supply chain achieves the best performance, and the supply chain profit is close to the theoretically optimal one (the centralized supply chain profit). In other words, a fair buyer helps to create a sense of cooperation between the supplier and herself.

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1. Introduction

1.1. Background of Study

In the textiles and clothing (TC) industry, supply chain contracts have been widely adopted to enhance the performance of supply chain. The well-explored and commonly implemented supply chain contracts in the TC industry[1] include returns contract (Pasternack 1985, Lau and Lau 1999), markdown money policy (Hausman and Thorbeck 2010), quantity-flexibility contract (Tsay and Lovejoy 1999, Tsay 1999), sales-rebate contract (Taylor 2002), and revenue-sharing contract (Cachon and Lariviere 2005). The benefits for these supply chain contracts are their ability in enhancing the supply chain's performance by dampening the double marginalization effect and allowing a proper share of risk and profit between buyer (e.g. retailer) and supplier (e.g. manufacturer). It is well known that under a two-echelon TC supply chain setting with a classical newsvendor type of fashion product, many of the above supply chain contracts can achieve supply chain coordination (SCC) with the quantity decision[2].

Among the supply chain contracts discussed above, the MMP is particularly popular and commonly implemented in the TC industry based on our industrial

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[1] Please see Chiu et al. (2011c) for some recent survey of the supply chain contracts in the TC industry.

[2] SCC represents the scenario under which the individual supply chain members will behave in way which maximizes the total supply chain system's profitability (Chopra and Meindl 2007).

observations. In fact, fashion brands (as suppliers) such as Liz Claiborne, and Tommy Hilfiger in the U.S.A. as well as Cocoon, and LX[3] in China all have adopted (or are adopting) the MMP in their supply contract offered to their retail customers. Under the MMP, the fashion brands help to reduce their retail customers' risk of having excessive inventory by the end of the season with a markdown sponsor. This is a very critical issue because, according to Hausman and Thorbeck (2010), department stores have heavy pressure on leftovers and 60-70% of them have to impose big discount (e.g. 40% off) as markdown in order to clear the inventory leftover. In fact, the MMP is widely implemented in fashion supply chains, and is usually initiated and requested by the fashion retailers such as the major fashion department stores (Women Wear Daily, June 7, 2005). For instance, Tommy Hilfiger, Liz Claiborne and the Jones Apparel Group were all asked to provide markdown money in the trade with department stores such as Macy's and JC Penney; if they refuse, the department stores will order much less than the original quantity and would end up with arguments (Rozhon 2005).

For the specific operations of the MMP, the following details are presented: The MMP is offered by the seller (e.g., the fashion brand) to the retail buyer and it includes both the wholesale price and the markdown sponsor parameters. With the

[3] For confidentiality issue, LX is a fictitious name for a real Chinese fashion company which will be explicitly introduced in Chapter 3.

MMP, the retail buyer needs to pay a wholesale price to the supplier in getting the supply and is also guaranteed by the seller to receive a certain amount of money for supporting markdown to clear inventory leftover at the end of selling season. For example, suppose that the seller (e.g. supplier) supplies a product to the buyer at a unit wholesale price of $100. If there is leftover at the buyer's place, the seller who offers the MMP will grant the buyer some money (e.g., $20) for each unit of the unsold product. This amount of money is termed as markdown money (and is also known as discount dollar or markdown incentive). This policy is quite similar to the returns policy with buyback (Pasternack 1985; Lau and Lau 1999; Choi et al. 2008), but it does not require the physical return of leftover products (see Tsay 2001 for the detailed discussions).

In this thesis, it focuses on examining the upstream supplier with the MMP in the TC supply chain. It is based on and motivated by several observations from the TC industry (for the full details of the related industrial observations, please refer to the Chapters 3). In fact, in recent years, the upstream TC suppliers suffered serious losses or even went bankrupt after several financial problems in Europe and the U.S.A. (including the current financial crisis in Europe and the global financial tsunami in 2008). According to Yeung et al. (2012), the 2008 financial tsunami has already "killed" hundreds of TC companies because of their poor cash flow control.

One aftermath of this event is the supplier in the whole apparel manufacturing industry are now much more risk averse than before. Thus, important questions are raised as to how *risk-averse* supplier affects the achievability of supply chain coordination under the MMP. In addition, our industrial observation implies the downstream TC buyer possesses a kind of self-serving fairness concern when dealing with her supplier. To be specific, the buyer's self-serving fairness can be measured by the (*minimum*) *profit share ratio* (MPSR) that the buyer can take from the supply chain. A high MPSR implies a strong self-serving fairness. Self-serving fairness affects an individual's preferences and favors its own payoff (Kaplan and Ruffle 1998). As a result, it is interesting to explore (i) the supplier's decision on the use of MMP if the buyers have the MPSR concern, and (ii) how the MMP affects the supply chain performance.

1.2. Research Objectives

In the literature, the strategy of clearance/markdown pricing from the retailer perspective has been largely discussed (Yin et al. 2009; Smith 2009; Caro and Gallien 2012). In this thesis, it focuses on studying the MMP from the TC supply chain perspective. This thesis contributes to the literature by being a pioneering study which aims at exploring how the supplier adopts the MMP for business growth and management in the TC industry. The specific research objectives are listed as follows:

1) To obtain a clear picture regarding the current industrial practices and challenges of MMP in the TC industry;
2) To examine various pertinent issues by case studies regarding the supplier's MMP adoption in the TC business;
3) To analytically examine the use of MMP with a risk-averse supplier in the supply chain and the respective channel coordination challenge;
4) To analytically and experimentally investigate the effect of the self-serving fairness concern with MMP on supply chain performance and dynamics;
5) To explore the challenges and future research directions for supply chain management in the TC industry.

1.3. Outline of Methodology

In this thesis, a multi-methodological approach is employed. Specifically, the following three methods are used:

(1) In-depth semi-structured interviews with two well-established apparel companies as target cases;

(2) Mathematical modeling (based on game theory and mean-variance theory)

approach, supplemented by numerical analysis;

(3) Behavioral experiments in a controlled laboratory environment and statistical data analysis.

The rationale of employing these approaches is as follows. Being the first step in this study, the case studies can help us gain a clearer picture about the current practices of MMP adoption in the TC industry. After obtaining the inspiration and motivation from case study in the TC industry, an analytical modeling research is conducted, which is able to deconstruct the mechanisms underlying complex real problem in industry and behavioral experiments are employed to create an environment to observe how human subjects behave in a specified scenario. Both analytical modeling research and behavioral experiments based on the industrial practices could generate insights on the TC supply chain with MMP from different dimensions. After obtaining the insights from analytical models and behavioral experiments, it can help better understand why the TC companies employ the MMP in such ways. The relationship of three methods is shown in Figure 1.1.

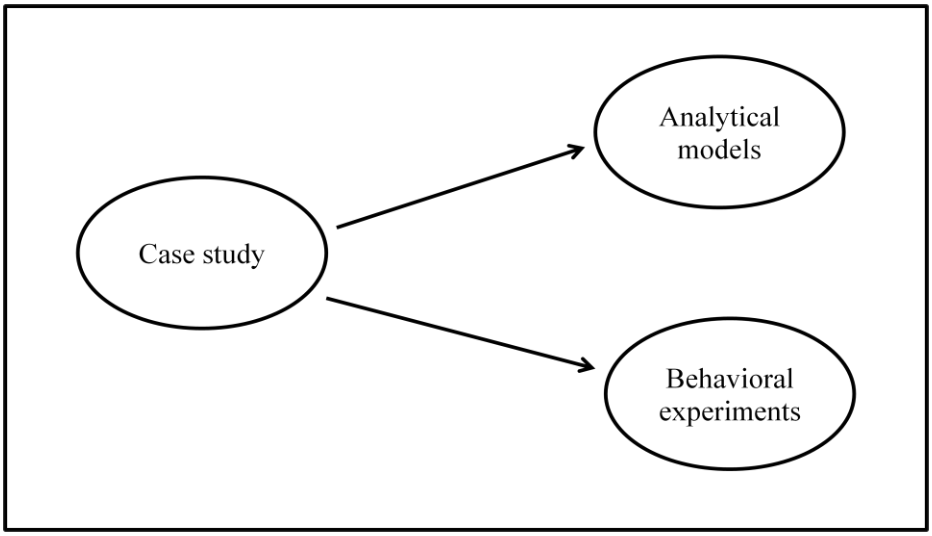

Figure 1.1 Multi-methodological approach

1.4. Significance of this Research

In this thesis, it focuses on studying the supply chain with MMP in the TC supply chain. The multi-methodological approach helps to reveal the implementation of MMP and their respective impacts on supply chain from different dimensions. Findings from this thesis research can help the upstream TC suppliers better understand the challenges of adopting the MMP as well as make more scientifically sound decisions. It contributes to the literature by achieving the objectives as defined in Chapter 1.2.

1.5. Organization of this Thesis

This thesis consists of seven chapters and its organization is as follows. It first presents a concise literature review on the related supply chain management problems in Chapter 2. Then the details of the interview cases with two TC companies regarding their practices of MMP adoption are reported in Chapter 3. Based on the industrial practices of the TC companies as revealed in Chapter 3, two technical analysis chapters, namely Chapter 4 and Chapter 5 are developed. In Chapter 4, the analytical model is presented. Through the mean-variance approach, it shows the impacts brought by having a risk-averse supplier in the supply chain; the respective supply chain coordination mechanisms, supplemented by extensive numerical analyses with real data, are explored. In Chapter 5, the analytical background is developed and the behavioral experiments are conducted to study the effect of self-serving fairness on TC supply chain under the MMP. Finally, this thesis is summarized in Chapter 6 and concluded with future research directions in Chapter 7.

2. Literature Review

2.1.Supply Chain Contracts by Analytical Study

2.1.1. MMP

As a popular supply chain contract, the MMP had a rich tradition in the TC industry (Ryan 1998; Monget 1998; Rozhon 2005; Lockwood and Beckett 2008). Based on those industrial practices, the MMP attracted the scholars to develop the analytical models for investigating the MMP in supply chain.

The MMP and the return policy are quite similar if the prices to the consumer market are endogenous[4] in the supply chain. It is known that they both can help the retailers to reduce risk of overstocking. However, the return policy incurs the physical cost of handling returns. In the literature, Tsay (2001) showed several MMP cases adopted in the TC industry. He compared the supply chain performance of MMP with the return policy and found that the physical costs of handling returns and relative advantages in liquidating unsold inventory can make return policy unattractive, thus offering the MMP might be more desirable for the supplier. His work was an important reference to show the advantages of MMP in the TC industry. Later, Hausman and Thorbeck (2010) examined the benefits of MMP on fast fashion operations. They presented a financial model to evaluate the profitability impact on

[4] In the majority of supply chain contract literature, it is assumed that the retail price is exogenously given.

markdowns in fast fashion. They indicated that the markdowns could lead to a significant percentage increase in the profits for the supply chain parties.

Wang and Webster (2009) discussed two forms of MMP under the background of the TC industry. One form of markdown money was quantity markdown money (QMM), in which the supplier paid a rebate credit to the retailer for each unsold unit at the end of the regular selling season. The other form of markdown money was called percent markdown money (PMM), in which the markdown money paid to the retailer was a certain percentage of the retail price markdown, i.e., the difference between the regular selling price and clearance price. They showed that both QMM contract and PMM contract could coordinate the supply chain and reduce the risk of overstocking. However, there existed a main difference between PMM and QMM in which the rebate depended on the end of season clearance price in a PMM contract whereas the rebate was specified at the start of the season in a QMM contract. Thus, if the end of season clearance price was known at the start of the season when the contract terms were set, then PMM and QMM contracts were identical. Their findings were insightful and gave guidance on whether the markdown price should be set at the start of the selling season or during the selling season. From the retailer perspective, some studies had explored the markdown policy as a dynamic pricing strategy during the selling season, in which the markdown pricing depended on the inventory level and market demand forecasting (Smith 2009; Caro and Gallien 2012; Mersereau and Zhang 2012). Lee and Rhee (2008) proposed a guaranteed profit margin scheme with the MMP for the coordination of a fashion apparel supply chain with one supplier and one retailer. They found that the retailer's optimal quantity decisions would result in profit maximization for the entire supply chain. Hence, the supply chain became fully coordinated and created win-win outcomes for both the retailer and the supplier. As a remark, the guaranteed profit margin scheme with the MMP was actually quite popular in the TC industry. For example, American fashion brand Liz Claiborne traded with department store JC Penney by the guaranteed profit margin scheme with the MMP, under which the supplier guaranteed the retailer's target mark-up rate even in the case of markdown sales. In addition to GPM with the MMP, the MMP was also popularly coupled with another supply chain contract. For example, Chinese fashion brand LX traded with their retailers by return policy with the MMP. Krishnan et al. (2004) studied the return policy with unilateral markdown money in supply chain when considering the promotion sales effort can affect the market demand. They analytically found that, under such scheme, the supplier was never worse off than without offering the markdown money.

Recently, scholars incorporated other factors such as lead time, risk issue and carbon emission tax into the investigation of the MMP adoption in the TC supply chain. For instance, Xiao and Jin (2011) investigated the effects of the lead-time-dependent demand uncertainty on the coordination mechanism of MMP and its corresponding channel profit for a fashion apparel supply chain. They found that the MMP can coordinate the supply chain with an exogenous retail price. Moreover, if the lead time increased, the supplier would charge the retailer a lower unit wholesale price to stimulate the order quantity and give a lower markdown allowance to restrict excess order if the basic demand uncertainty was sufficiently large. Further, Choi (2013a) examined the MMP in the TC supply chain with the risk-averse retailer under a multi-period fashion supply chain. He showed that when the retailer was risk-averse, her optimal order quantity was increasing in the markdown price. In addition, the MMP also had an impact on green supply chain management. For example, Choi (2013b) investigated how the carbon footprint tax affected the supply chain agents in making the optimal sourcing decision with the MMP. He indicated that under the supply chain with the appropriately set carbon footprint tax, sourcing locally would become a wiser choice than offshore sourcing for the supply chain members.

In reality, the timing and frequency of markdown had a significant impact on consumer behavior. When the consumers were strategic, they could learn to anticipate future price reductions and forego purchasing products until markdowns occurred. Over the past 6 years, it was quite a popular topic in supply chain management to study the MMP with strategic consumer behavior. In fact, Su (2007) pioneered a study on exploring the MMP in the presence of strategic (forward looking) consumers. He investigated the optimal pricing problem under MMP with strategic consumer and found that the MMP was effective because high-value customers were proportionately less patient and willing to purchase early at high prices. Later on, Su and Zhang (2008) further extended the analysis in Su (2007) and showed that a strong manufacturer such as a luxury fashion brand should adopt the MMP in which a higher wholesale price was charged. Cachon and Swinney (2009) studied the interaction between a retailer's stocking decision and its markdown strategy in the presence of strategic consumers with a lot of discussions related to the TC industry. They found that it was not the best strategy to have a commitment on "never having markdown on products" when dealing with strategic consumers. The summary of MMP related research is shown in Table 2.1.

Table 2.1 The summary of MMP related research

Paper	**TC specific?**	**Research Focus**	**Core Findings**
Tsay (2001)	No	Supply chain performance comparison between the MMP and the return policy.	The physical costs of handling returns and relative advantages in liquidating unsold inventory could make return policy unattractive, thus offering MMP might be more desirable for the supplier.
Hausman and Thorbeck	Yes	The benefits of MMP on fast fashion.	The markdowns led to a significant percentage increase in the profits for the

(2010)			supply chain parties.
Wang and Webster (2009)	Yes	Quantity markdown money (QMM) and percent markdown money (PMM).	If the end of season clearance price was known at the start of the season, then PMM and QMM contracts were identical.
Lee and Rhee (2008)	Yes	A guaranteed profit margin scheme with the MMP for the channel coordination.	The retailer's optimal quantity decisions would result in profit maximization for the entire supply chain.
Krishnan et al. (2004)	No	The return policy with unilateral MMP in the sales effort dependent demand.	The supplier was never worse off than without offering the markdown money.
Xiao and Jin (2011)	Yes	Channel coordination with the lead time dependent demand in the MMP.	When the lead time increased, the supplier would charge a lower wholesale price and while gave a lower markdown allowance.
Choi (2013a)	Yes	The risk-averse retailer with the MMP under a multi-period supply chain.	When the retailer was risk-averse, her optimal order quantity was increasing in the markdown price.
Choi (2013b)	Yes	The impact of carbon footprint tax on sourcing decision with the MMP.	Sourcing locally was always a wiser choice for the supply chain members with the carbon footprint tax.
Su (2007)	No	Strategic consumer behavior in the MMP	The MMP was effective because high-value customers were proportionately less patient and willing to purchase early at high prices.
Su and Zhang (2008)	No	Supply chain performance with the MMP in the presence of strategic customer behavior	A strong manufacturer such as a luxury fashion brand should adopt the MMP in which a higher wholesale price was charged.
Cachon and Swinney (2009)	Yes	Retailer's stocking decision and its markdown strategy in the presence of strategic consumers.	It was not the best strategy to have a commitment that never markdown products when dealing with strategic consumers.

2.1.2. Other Supply Chain Contracts

In addition to the MMP and the return policy, the literature also explored various other supply chain contracts. Some of them are reviewed as follows.

In the TC industry, a commonly seen quantity flexibility contract was described as a backup agreement (Eppen and Iyer 1997). Eppen and Iyer (1997) analyzed "backup agreements, which allowed the buyer to return a portion of her purchase to the supplier. Eppen and Iyer's analysis indicated that backup arrangements could have a substantial impact on expected profit and might result in an increase in the committed quantity. In a quantity flexibility clause, the quantity the retailer ultimately purchased might deviate from a previous planning estimate and a kind of credit transfer results. As such, Tsay and Lovejoy (1999) stated that the quantity flexibility contract could coordinate the materials and information flows in supply chains operating under rolling-horizon planning. At the same time, Tsay (1999) studied the quantity flexibility contract, in which it was coupled with the retailer's commitment to purchase more than a certain percentage below the forecast with the supplier's guarantee. This contract could allocate the costs of market demand uncertainty so as to lead the individually motivated supplier and retailer to the system-wide optimal outcome. Bassok and Anupindi (2008) analyzed the flexibility contracts in a multi-product context, in which the buyer was required to commit a minimum cumulative dollar value of purchases during a specified time horizon to be eligible for receiving a percentage discount off regular prices. They interestingly found that the flexibility to increase purchases at the lower price was not particularly critical.

Channel rebate was another popular supply chain contract widely seen in the TC industry. The channel rebate was a payment from a supplier to a retailer based on the amount of retail-sales to end consumers. The first piece of rebate study in analytical supply chain management studies was Taylor (2002) in which he investigated two common forms of channel rebates (linear rebates and target rebates). The linear rebate was paid for each unit sold, and target rebate was paid for each unit sold beyond a specific sales target level. Taylor (2002) indicated that the properly-designed target rebate can achieve channel coordination when the demand was not influenced by sales effort, but the linear rebate could not achieve coordination. Krishnan et al. (2004) studied the channel rebate contract in supply chain. They considered the sequence of action that the retailer first chose an order quantity, a signal of demand was observed and then effort was exerted. They found that if the demand signal was strong relative to the order quantity, then the retailer did not need to exert much effort. Chiu et al. (2011c) studied a hybrid contract called pricing, return and rebate (PRR) policy, in which three contracts were combined: wholesale pricing contract, return policy and target sales rebate contract. They found that a PRR policy can achieve supply chain coordination under both an additive form and a multiplicative form of price-dependent demands. They also showed that it was possible to set the optimal contract parameters for the equilibrium PRR contract so that channel coordination along with Pareto improvement could be achieved.

The clauses of revenue-sharing contract stated that the retailer gave the supplier a percentage of his revenue as a part of the supply contract while the supplier needed to grant a very favorable wholesale price to the retailer (in some cases, the supplier may even supply at cost). In fashion apparel, revenue-sharing contract usually took the form of consignment. Cachon and Lariviere (2005) studied the revenue sharing contract, in which a retailer paid a supplier a wholesale price for each unit purchased, and added a percentage of the revenue the retailer generated. They stated that the revenue sharing contract and return policy were equivalent in this setting in the strongest sense: For any return policy, there existed a revenue-sharing contract, which generated the same cash flows for any realization of demand. The revenue sharing contract could also coordinate that supply chain (with a single-dimensional quantity only decision). Mortimer (2008) examined the welfare effects of revenue-sharing contracts in the retailing industry. She found that the revenue-sharing contracts had an important and substantial impact of social welfare, and increased profits for supply chain agents and consumer surplus. A summary of the reviewed supply chain contracting research is shown in Table 2.2.

Table 2.2 The summary of other supply chain contracts (non-MMP) research

Paper	**TC specific?**	**Research Focus**	**Core Findings**
Bassok and Anupindi (2008)	No	Quantity flexibility contract in a multi-product context.	Flexibility to increase purchases at the lower price was not particularly critical.
Eppen and Iyer (1997)	Yes	The benefits of backup agreement for supply chain agents	Backup arrangements had a substantial impact on expected profit and might result in an increase in the committed quantity.
Tsay and Lovejoy (1999)	No	Quantity flexibility contract in supply chain coordination.	Quantity flexibility contract could coordinate the materials and information flows in supply chains operating under rolling-horizon planning.
Tsay (1999)	No	Quantity flexibility contract with retailer's quantity commitment.	This contract could allocate the costs of market demand uncertainty so as to lead the individually motivated supplier and retailer to the system-wide optimal outcome.
Taylor (2002)	No	Linear rebates and target rebates.	The properly-designed target rebate could achieve channel coordination when the demand was not influenced by sales effort, but the linear rebate alone could not achieve coordination.
Krishnan et al. (2004)	No	channel rebate contract in supply chain with sales effort consideration	If the demand signal was strong relative to the order quantity, then the retailer did not need to exert much effort.
Chiu et al. (2011c)	Yes	A hybrid contract so called PRR policy (wholesale pricing, return and target sales rebate policy).	A PRR policy could achieve supply chain coordination under both an additive form and a multiplicative form of price-dependent demands.
Cachon and Lariviere (2005)	No	Revenue sharing contract with its ability of supply chain coordination.	They stated that the revenue sharing contract and return policy were equivalent in this setting in the strongest sense. The revenue sharing could also coordinate the supply chain (with a single-dimensional quantity only decision).
Mortimer (2008)	No	The welfare effects of revenue-sharing contracts	The revenue-sharing contracts had an important and substantial impact of social welfare, and could increase profits for supply chain agents and consumer surplus.

2.2.Supply Chain Coordination with Risk-Sensitive Agents

Risk attitude represented a generic orientation (as a mind-set) towards taking or avoiding a risk when deciding how to proceed in situations with uncertain and unfavorable outcomes. Risk attitude included three types: risk prone, risk neutral and risk averse. Risk prone implied the risk-seeking attitude towards taking risk; risk averse implied the attitude towards avoiding risk, and risk neutral supply chain decision maker was always an optimizer of expected measure (e.g., profit, cost). The risk attitude of the agents (e.g. retailer, supplier) in a supply chain towards demand uncertainty played an important role in their decisions (Webster and Weng 2000; Tsay 2002, Wang et al. 2009, Chiu et al. 2011b). With the consideration of risk preference, the objectives for the agents in supply chain were trying to maximize their utility other than solely their expected profits. In the business world, it was usually assumed that rational decision makers for companies were risk averse. As a consequence, the respective objective function (or utility function) was an increasing function of payoff (e.g. expected profit), but a decreasing function of the risk.

The variation/uncertainty of the profit or cost also had a strong impact on the performance of the supply chain parties. The different parties might have different tolerance levels toward the uncertainty, or the risk. Consequently, it was also important to incorporate the risk-related measures into the supply chain coordination problems. In the literature, Eeckhoudt et al. (1995) studied the effect of risk aversion in the single period newsboy problem. They examined what changes in price and cost parameters related to the member's risk aversion. Agrawal and Seshadri (2000b) considered how a risk-averse retailer (with a concave and "increasing in wealth" utility function) would make decision on the order quantity and the selling price in a single-period inventory model. Two different demand distributions for price were discussed by them: in the first model, they assumed that a change in the price would affect the scale of the distribution, and they found a risk-averse retailer would charge a higher price and order less as the risk aversion increases; in the second model, a change in the price only affected the location of the distribution, and they showed that a risk-averse retailer would charge a lower price and order more as the risk aversion increases. Agrawal and Seshadri (2000a) had explored a supply chain with multiple risk-averse retailers who purchased a single product from a common supplier in a single period. They introduced a risk-neutral intermediary into the channel, who purchased goods from the vendor and sold them to the retailers. The intermediary ordered the optimal newsvendor quantity from the supplier and offered a menu of mutually beneficial contracts to the retailers. The menu of contracts simultaneously induced every risk-averse agent to select a unique contract from it, maximized the distributor's profit, and raised the order quantities of the retailers to the expected value maximizing quantities. Afterwards, research had been extended to both risk-averse retailer and supplier domain. For example, Tsay (2001) studied how both the risk-averse supplier and retailer affected the relative strategic power and how these dynamics were altered by the introduction of the return policy. Tsay (2001) indicated the quantitative difference of the behavior under risk aversion and risk neutrality. He also showed that the penalty for errors in estimating a channel partner's risk aversion could be substantial.

2.3.Mean-Variance Approach in Supply Chain Coordination

The mean-variance (MV) approach (a Nobel Prize winning theory) was a fundamental theory for portfolio management in finance. It was first proposed in the field of finance by Markowitz (1959). Later, this theory was applied to other fields such as supply chain optimization. In supply chain management, since the significance of the expected performance measure highly depended on the associated variance (Choi et al. 2008a), the traditional studies in supply chain management which focused solely on optimizing the expected measures lacked precision. The pioneering work of mean-variance in supply chain management was Lau (1980), who used the MV approach to study basic inventory control problems. After that, a number of studies had emerged and adopted the MV approach. For instance, Lau and Lau (1999) used mean-variance objective functions as the supply chain members' objectives to study a two-echelon supply chain problem in a single period. They found that the members' risk attitudes determined the optimal return policy significantly.

Gan et al. (2004) showed a new definition of supply chain coordination in risk sensitivity issue by mean-variance approach. They considered three specific cases of a supply chain: (i) the supplier was risk neutral and the retailer maximized his expected profit subject to a downside risk constraint, (ii) the supplier and the retailer each maximized its own mean-variance tradeoff, and (iii) the supplier and the retailer each maximized its own expected utility. Later on, Gan et al. (2005) considered the channel coordination issue that the supply chain consisted of a risk-neutral supplier and a downside-risk retailer. They designed a risk-sharing contract with a downside risk formulation, and the supply chain coordination could be achieved under that contract. Choi et al. (2008a, b, c and 2011) applied the MV model to analyze supply chain coordination problem. For example, Choi et al. (2008a) studied supply chain coordination with a risk-averse retailer. They made comparison of the supply chain expected performance between the model with risk control and one without risk control. They also examined the supply chains under centralized and decentralized settings. Wei and Choi (2010) conducted a mean-variance analysis on a two-echelon supply chain based on the observed industrial practice on wholesale pricing and profit sharing policy. They established the analytical closed form necessary and sufficient conditions for coordinating the supply chain by a wholesale pricing and profit sharing scheme under an information symmetric case. They then studied the case with information asymmetry and showed that the retailer could be beneficial by pretending to be more risk-averse. They proposed to use a minimum quantity commitment scheme for the manufacturer to avoid the retailer's cheating case from happening. Chiu et al. (2011a) conducted a mean-variance analysis of a supply chain under target sales rebate contract. They showed how a target sales rebate contract can achieve supply chain coordination in different scenarios. Since the MV analysis was very popularly conducted in supply chain management, it was also adopted in some of our models in this thesis. To be specific, in Chapter 4 of this thesis, the impact of a risk-averse supplier on the TC supply chain was explored under the MV framework. Some representative literature related to supply chain risk analysis is summarized in Table 2.3.

Table 2.3 Some related literature on supply chain risk analysis

Paper	TC specific?	Risk averse objective (MV/ non-MV)
Lau (1980), Eeckhoudt et al. (1995), Webster and Weng (2000), Wang et al. (2009), Xiao and Choi (2009)	No	Non-MV
Lau and Lau (1999), Agrawal and Seshadri (2000a), Tsay (2001), Gan et al. (2004, 2005), , Choi et al. (2008a, b, c and 2011), Chiu et al. (2011a)	No	MV
Chiu et al. (2011b)	Yes	Non-MV
Vaagen and Wallace (2008), Li et al. (2012), Choi (2013a)	Yes	MV

2.4.Supply Chain Contracts by Behavioral Study

A number of studies used laboratory experiments to examine the performance of supply chain contracts. Keser and Paleologo (2004) investigated a wholesale pricing contract in a two-echelon supply chain by assuming that demand was stochastic. They observed that participants in the role of supplier would charge lower wholesale prices than those predicted by the sub-game perfect equilibrium solution and retailers ordered less than the predicted best response to those wholesale prices. Moreover, retailers were more likely to reject contracts with higher wholesale prices, and suppliers tended to choose wholesale price contracts that split profits approximately equally. In laboratory experiments, Katok and Wu (2009) compared wholesale price contract, buyback contract and revenue-sharing contract. They found that coordinating contracts (buyback and revenue-sharing contracts) improved supply chain efficiency relative to the non-coordinating contracts (wholesale price contract), but the improvement was smaller than the respective theoretical results would have predicted. For supplier behavior, they found that when coordinating contracts were adopted, human suppliers did not offer contract parameters that could fully coordinate the supply chain, even when retailers were programmed to order optimally.

Haruvy et al. (2012) examined the performance of the wholesale price contract and the two-part-tariff contract. They found that those coordinating contracts failed to coordinate, and might even reduce supply chain efficiency, primarily due to retailer rejections. They reached a conclusion similar to that of Keser and Paleologo (2004) that supply chain parties tended to split the channel profit close to 50-50. In addition, Haruvy et al. also found that a slightly more dynamic bargaining protocol not only would improve the performance of the two-part-tariff contract dramatically, but would also decrease the loss aversion bias as well as increase inequality aversion.

Kalkanci et al. (2011) investigated the effect of contract complexity and asymmetric information on supply chain performance in a two-echelon supply chain. They compared a price-only contract and a quantity discount contract (with two or three price blocks) in which a supplier interacted with a computerized buyer under asymmetric demand information. They showed that simple contracts such as a price-only contract or a quantity discount contract would perform effectively under asymmetric demand information.

Davis and Katok (2012) explored how three different inventory risk allocation schemes—push, pull, and advanced purchase discount (APD)—affected the supply chain performance. The push contract incurred the risk from the retailer and the pull contract incurred that one from the supplier. Their experimental results indicated that the pull contract obtained higher supply chain efficiency than that of a push contract. Their experimental results also showed that retailers preferred the pull contract, whereas suppliers preferred the push and advanced purchase discount contracts. In addition, the APD contract combined certain features of push and pull by allowing both parties to share the inventory risk. They observed that the retailers were better off and suppliers were no worse off under the APD contract.

Wu (2013) looked at the interactive behaviors that had developed over a perceived long-term contractual relationship and investigated wholesale price contract, buyback contract and revenue-sharing contract under the environment of stochastic demand. Her experimental results indicated that participants systematically deviated from predictions by the normative model that assumed a one-shot interaction between self-interested players. She found that when future opportunities to punish were available, social preferences for fairness and reciprocity were reinforced; and reputation-building behaviors were motivated to achieve long-term economic benefits. As a result, the performance of the overall supply chain was enhanced.

2.5. Reservation Profit Level in Supply Chain

Reservation profit level (RPL) had been widely explored in the supply chain management literature. In Cachon (2003), RPL was treated as a means to model a firm's bargaining power in which a supply chain agent accepted a contract only if the contract achieved at least its own RPL and a higher RPL implied that the agent held a higher bargaining power in the supply chain. Corbett et al. (2004) considered a vertical contracting environment with one supplier and one retailer. They assumed that each player had an exogenously given RPL, below which they refused to trade. In contrast to Cachon (2003) and Corbett et al. (2004), Bernstein and Marx (2006) considered a scenario in which the RPL endogenously depended on the retailer's opportunities within the supply chain; they investigated the effect of the retailer's RPL on the allocation of total supply chain profit among all of the channel members. Cachon and Kok (2010) considered a supply chain in which two manufacturers distributed substitutable products through a common retailer. They compared three supply chain contracts and showed that the retailer's RPL depended on the contract type offered by the manufacturer; thus, competition between manufacturers enabled the retailer to capture more of the supply chain profit. In the aforementioned studies, RPL was defined as an absolute number that is either endogenously determined or exogenously given. In the analysis presented in Chapter 5, the minimum profit share ratio (MPSR) was discussed, where MPSR was defined as a constant ratio. Similar to the concept of RPL, a higher MPSR implied a higher bargaining power. Exploiting bargaining power was one way of showing people's fairness (Binmore et al. 1991).

2.6.Fairness in Supply Chain

Recently, the issue of fairness had become a hot topic in the supply chain management literature. Cui et al. (2007) were the first to model fairness concerns in the context of supply chain coordination. They assumed that fairness concerns were public information and they identified two types of retailers' inequality aversion, which had different effects on supply chain coordination: aversion to disadvantageous inequality and aversion to advantageous inequality. Under the effect of aversion to disadvantageous inequality, a retailer was only concerned with avoiding making less profit than the supplier. Cui et al. (2007) theoretically proved that aversion to disadvantageous inequality worsened supply chain inefficiency, as it would cause the retailer to *punish* the supplier by setting an excessively high market price. Unlike Cui et al. (2007), in Chapter 5, fairness concerns were considered as private knowledge, and thus in our model the retailer was only concerned with avoiding making less profit than what her MPSR concerns. It was similar to Pavlov and Katok (2012), in which they aimed to explain the rejections based on fairness and bounded rationality in behavioral experiments when fairness concern was private information. They found that due to incomplete information in fairness concern, the supply chain contracts that were coordinating in theory might not actually coordinate the channel even in the absence of bounded rationality. In addition, in the reported experiments in Chapter 5, the retailer would punish the supplier by rejecting the contract if the provided contract did not satisfy her MPSR concern.

As a remark, rather recently, many scholars studied the fairness concern in the context of supply chain contracts. For example, Katok et al. (2012) investigated fairness concern in the context of a wholesale price contract. They found that the contract can coordinate the channel under the sufficient fairness concern, but that the supply chain was less efficient if fairness concerns were not strong. Katok and Pavlov (2013) followed Cui et al. (2007) to incorporate the fairness concern into model. They indicated that when the supplier had incomplete information about the retailer's preferences for fairness, a theoretically coordinating contract might not, in fact, coordinate the supply chain. In their laboratory experiments, to cleanly control and manipulate the information, the role of the retailer was played by the computer.

Ho et al. (2013) experimentally investigated how distributional and peer-induced fairness concerns interacted and how this affected supply chain performance. Their experimental data suggested that a peer-induced fairness concern was more salient than a distributional one.

The concept of fairness emerged from equity theory (Pavlov and Katok 2012), which was first developed by Adams (1965) in his study of employer-employee relationships in the workplace. Recently, equity theory had been applied to study fairness in supply chain management (Pavlov and Katok 2012). According to Scheer et al. (2003), equity theory implied that a party evaluated an ongoing relationship by assessing his or her own inputs into and returns from the relationship, relative to what the other parties contributed to and received from the relationship. When a supplier faced an MPSR-concerned retailer, he evaluated her self-serving fairness by offering a contract, and in return he received not only the retailer's acceptance or rejection based on her MPSR, but also a percentage of his profit over the whole supply chain.

To fill the research gap in self-serving fairness in the TC supply chain, in this thesis, the effect of the retailer's self-serving fairness on the performance of both individual channel members and the whole TC supply chain under the MMP were investigated in a controlled laboratory setting. The summary of reviewed literature with behavioral studies was shown in Table 2.4.

Table 2.4 The summary of reviewed literature with behavioral studies

Paper	**TC specific?**	**Contract type**	**Fairness**	**Core Findings**
Keser and Paleologo (2004)	No	Wholesale price contract	No	Retailers were more likely to reject contracts with higher wholesale prices, and suppliers tended to choose wholesale price contracts that split profits approximately equally.
Katok and Wu (2009)	No	Wholesale price contract, buyback contract and revenue-sharing contract	No	Coordinating contracts (buyback and revenue-sharing contracts) improved supply chain efficiency relative to the non-coordinating contracts (wholesale price contract), but human suppliers did not offer contract parameters that could fully coordinate the supply chain, even when retailers were programmed to order optimally.
Haruvy et al. (2012)	No	Wholesale price contract and the two-part-tariff contract	No	A slightly more dynamic bargaining protocol not only would improve the performance of the two-part-tariff contract dramatically, but would also decrease the loss aversion bias as well as increase inequality aversion.
Kalkanci et al. (2011)	No	Price-only contract and a quantity discount contract (with two or three price blocks)	No	Simple contracts such as a price-only contract or a quantity discount contract performed effectively under asymmetric demand information.
Davis and Katok (2012)	No	push, pull, and advanced purchase discount	No	The pull contract obtained higher supply chain efficiency than that of a push contract. Retailers preferred the pull contract, whereas suppliers

		(APD) contract		preferred the push and advanced purchase discount contracts. In addition, the APD contract combined certain features of push and pull by allowing both parties to share the inventory risk.
Wu (2013)	No	wholesale price contract, buyback contract and revenue-sharing contract	No	When future opportunities to punish were available, social preferences for fairness and reciprocity were reinforced; and reputation-building behaviors were motivated to achieve long-term economic benefits. As a result, the performance of the overall supply chain was enhanced.
Ho et al. (2013)	No	wholesale price contract	Yes	A peer-induced fairness concern was more salient than a distributional one.
Katok et al. (2012)	No	wholesale price contract	Yes	Wholesale price contract could coordinate the channel under the sufficient fairness concern, but that the supply chain was less efficient if fairness concerns were not strong.

3. Case Study: MMP Adoption in the TC industry

3.1. Case Study

In the TC industry, companies faced a high and volatile demand uncertainty because of the fast-changing consumer tastes (Barnes and Lea-Greenwood 2006; Bruce and Daly 2006). Efficiency enhancement measures such as quick-response policy (Bergvall-Forsberg and Tower 2007; Bruce and Daly 2011) for adopting the fast-changing consumer demand were hence launched. In addition, an effective supply chain contract among the various parties along the TC supply chain was critical for long-term success.

The decisions, management practice, and the overall strategy related to supply chain contracting were also affected by the national culture (Metters et al. 2010). In the literature, Hofstede's national cultural dimensions theory was well-established to explain the cultural problem, and its four cultural dimensions (i.e., power distance, individualism/collectivism, masculinity/femininity, and uncertainty avoidance) described the effects of a national culture on the values of its members' behavior (Hofstede, 1984). Taking U.S.A. and China as examples, U.S.A. culture had a lower score than China in the power distance dimension (40 in U.S.A. vs 80 in China), but much higher than China in individualism (91 in U.S.A. vs 20 in China) (please see Figure 3.1). Due to national culture, the differences between East and Western companies to make decision in operation management practices would probably be obvious. Particularly in supply chain contracting, national culture would cause supply chain contracts to be structured differently between East and West (Cai et al. 2010). Among Chinese suppliers, the normal mode of operation was trust based (i.e., guanxi), while in contrast the Western firms that preferred to operate on more formal contracts (Li et al. 2010). In the existing literature, however, it rarely explored the effect of national culture on supply chain contract adoption. To fill this research gap and to motivate further technical analysis, in this chapter, case studies were conducted to investigate how companies (with distinctive national cultures) employed supply chain contracts (e.g. MMP) in a supply chain from the TC companies in U.S.A. and China, respectively.

Low Power Distance	High Power Distance	
	China	Collectivism
U.S.A.		Individualism

Figure 3.1 Power distance and individualism/collectivism in the U.S.A. and China

3.1.1. Methodology

Case study is a well-established research method in business studies. Case study consists of detailed investigations (from one or more organizations, or groups within organizations) alongside data collection, with a view of providing an analysis of the context and processes involved in the phenomenon under study (Yin 2009). A case study in supply chain offers the opportunity to study a phenomenon in its own natural setting where complex links and underlying meanings are explored (Metters 2008; Oke and Gopalakrishnan 2009; Oliva and Watson 2011). Since the aim of case studies is on generating in-depth contextual information of supply chain contracts adoption from the cross-cultural perspective, it may result in a superior level of understanding. As the cross-cultural study and exploratory research in supply chain contract implementation, the use of a case study research strategy is considered suitable in this chapter.

The case studies reported in this chapter were developed primarily from individual in-depth interviews. To ensure the comparability, two companies were selected and one came from U.S.A. and one from China. These two companies were in a similar position of their corresponding market in terms of their market size and playing the same role (i.e. supplier) along the TC supply chain. To be specific, the interviews were conducted with the former executive manager of Liz Claiborne in

U.S.A. and the general manager of LX[5] in China. As a cross-cultural study between U.S.A. and China, the interview protocol of the MMP implementation was first designed in English and then translated it into Chinese. The interview protocol was shown in Appendix. To ensure the accuracy of translation, an independent researcher was invited to translate it from Chinese to English. The interview protocol was structured by asking open-ended questions. The interviewees were able to fully express their view. In order to allow analysis and discussion, the interviews were recorded and transcribed, interpreted, coded and displayed (Miles and Huberman 1989; Yin 2009).

In this chapter, following the relevant literature, a case study methodology was employed to derive insights and propose future research directions. For the primary data collection process, multiple methods were employed (Yin 2009), including face-to-face semi-structured interviews with staff members (as described above) from the investigated firms, and also some publicly available news and statistics from the company's website, and annual reports. Notice that the materials from these multiple sources were used for triangulation purpose which helped enhance the reliability of the findings (compared to the case analysis which solely relied on one single source of information, such as interview, which could be much biased) (Yin

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[5] For confidentiality issue, LX is a fictitious name for a real Chinese fashion company (please see Section 3.1.3. for the details).

2009).

With the case study method defined, the case findings on the implementation of MMP in Liz Claiborne in U.S.A. and LX in China were presented in the following section. As a remark, in order to explore the impact of national culture on MMP applications in supply chain, it was significant to study the implementation of MMP in TC companies in U.S.A. and China. The managerial insights for both local and global business in the TC industry were delivered.

3.1.2. Case one – Liz Claiborne

3.1.2.1. Company Overview

Liz Claiborne (LC) is a fashion company founded in 1976 in New York City and renamed as Fifth & Pacific Companies[6]. The LC designs a wide range of women's and men's apparel, accessories and fragrance products. The LC was also the first brand to insist that its product collections must be placed together on the same floor, instead of in separate clothing categories. This retail format had changed the consumer buying habit because shoppers no longer went from shirt department to pant department to coordinate an outfit. They were able to mix and match pieces from the LC's collection to create entire outfits. This revolutionized the way department stores arranged clothing for sale and created the role of fashion merchandising. As a famous fashion brand, the major department store such as JC Penney and Macy's were the retail partners of LC. In 2010, the LC officially sold several brands including the Liz & Co, the Claiborne and the Monet to JC Penney and shifted focus to three brands – Juicy Couture, Kate Spade and Lucky Brand Jeans (Source: from Fifth and Pacific website).

[6]We keep using LC in this thesis for the sake of convenience.

3.1.2.2.Implementation of MMP

The LC traded with its retailers by the GPM with MMP. Specifically, if the retailers did not reach their expected profit margins, the goods would either fail to catch on with consumers or sell at deeply discounted prices, and then the retailers would ask the LC to make up the difference on a line that did not sell at full price (Bird and Bounds 1997; Rozhon 2005). The former executive manager in the LC pointed out that:

"We designed a new plan from the retailer every six months, which can vary from season to season, but only slightly. However, JC Penney required the LC to guarantee a margin by the end of the season. They may tell us at the beginning of the season that they wanted our product to net a 55% margin. So however we got there, either by markdown money or great sell through, it does not matter."

Markdown money is frequently asked by the fashion retailers such as department stores in the U.S.A. (Edelson 2005), which was not an exception in the LC. Large department stores including JC Penney and Macy's had a self-serving fairness concern, namely, minimum profit share ratio, below which they would use their retail bargaining power and threaten not to place orders for the upcoming season (Krishnan and Soni 1997; Rozhon 2005). However, the suppliers accused the retailers of marking down items more aggressively than necessary and refused to share their burden of lost margins. The costs of markdowns actually brought a heavy financial burden to the LC. A statement from Robert Zane, Chairman of the U.S.A. Association of Importers of Textile & Apparel and former sourcing executive in the LC was listed below:

"Willingly or unwillingly, we happily trade time for comfort. The most expensive elements of a slow time to market do not even appear on the cost sheets: the costs of markdowns" (Beckett 2006).

Interestingly, the former executive manager in the LC also mentioned that, in the past, the supplier did not provide the markdown money. The merchandisers were given a bonus based on what they "sell in"[7]. Therefore, their sales executives would sell as much product to the retailers as they could, without worrying the leftover at the end of the season, and they thought it was "not their problem", until the retailers began asking for markdown money in recent years. Once the retailers started to ask for the markdown money, the supplier was difficult to "sell in". Then more and more

[7]Sell-in deals with what was sold to the retailer in the supply chain.

companies, including the LC, were adapting a “sell through”[8] scheme where the supplier was responsible for “sell through” but not “sell in”. This implied that the retailer would report back to the supplier, the sell through for the product and the sales person would get a bonus based on an actual sell through percentage. Suppliers started to care about the leftover because of MMP. The former executive manager in the LC said that:

“We know what we have to achieve at the beginning of the season, so we can plan our product and the recommended quantity buys accordingly. We work closer and our relationship is more like a team. But still when the product sells and the retailer are making money, they love us! If our product does not sell, then there is not that much love.”

MMP actually helped the supplier and the retailer to build up a better relationship. The Americans focused on their own interest when their business involved cooperation.

[8]Sell-through deals with what the retailer interacting with the final customer was able to sold.

3.1.2.3.Summary

For the LC, providing the markdown money to its retailer (i.e., JC Penny) was actually involuntary. In this two-echelon supply chain (e.g. the LC is the supplier and JC Penney is the retailer), the LC had less bargaining power. The markdown money was a kind of "incentive money" for the LC to ensure the business can be continuous.

There are several insights based on the implementation of MMP in the LC. First, economic circumstance affected the supply chain agents to make decision on contract adaptation. Markdowns and markdown money were significant in unfavorable economic season for the retailer. Due to financial tsunamis in 2008, the American economy was weak and consumption in fashion was continuously dropping afterwards. The retailers such as department stores had faced huge pressure on poor cash flow and inventory control. Markdown was a direct way to quickly reduce the inventory level and obtain a healthy cash flow. To maintain the profit margin, the retailers, such as the department stores, asked the fashion brand to provide the markdown money to compensate for the unsatisfied sales performance. To ensure the business can be sustainable, the LC was basically forced to provide the markdown money to JC Penney.

Second, the cultural factors such as power distance and individualism could partially explain the behavior of American firm in dealing with the supply chain contracts. This finding was also confirmed by Cai et al. (2008) and Li et al. (2008). In the U.S.A., the supply chain parties were more willing to bargain the contract terms in trading. This can be potentially explained by the power distance, which was known to be relatively neutral in the U.S.A. (Hofstede 2001). The U.S.A. scored generally low on this dimension which was in line with the American premise of "liberty and justice for all" (Griffith and Myers 2005). After bargaining, as a less powerful party under the unfavorable economic environment, a fashion brand had to promise the GPM with MMP; while in return, it could establish a long-term business partnership with the retailers. Moreover, the American firms insisted on contractual arrangement as a way to manage supply chain because they believed the formal contracts could protect their own interests, so that the partners would tend to focus on the original goals and aspirations. The self-interests behavior, called self-serving fairness, was a part of all active relationships in supply chain (Narasimhan et al. 2009; Wang et al. 2013). Self-serving fairness affected an individual's preferences and favored one's own payoff (Kaplan and Ruffle 1998). This phenomenon could be explained by the evidence that the Americans were believers in individualism, which implied that they are more likely to rely on their own view to make decision and cared more about their own interests (Hofstede 2001).

3.1.3. Case two – LX

3.1.3.1. Company Overview

Similar to the LC, LX is also a fashion company, producing fashion products such as T-shirts, sweaters, jackets, padded snow suits, casual pants, and denim, and selling them to their retailers. Their retailers are responsible for selling to the end customers. The LX was founded in 2001 and its headquarters is in Shanghai, China. In 2010, its sales volume exceeded 1.1 billion RMB with over 400 downstream retailers in China (Source: from the website of LX).

3.1.3.2. Implementation of MMP

The LX adopted the MMP. Specifically, before the selling season, the LX first announced the details in its contract and required the retailers to order a minimum order quantity (MOQ). The retailers then placed an order which must be equal to or above the MOQ. In the middle of the selling season, by sharing the sales data, the LX might offer the markdown money for supporting the retailers to mark down and helping them to reduce inventory. A higher level of inventory, a higher amount of markdown money might be provided. At the end of season, the leftovers would be bought back at the committed return price and shipped to the LX. The leftovers would then be sold in the LX's online store in Taobao (the biggest and most popular

B2C online store in China). The general manager in the LX said that:

"We try to help our retailers to sell quickly and reduce the inventory. We give them some support such as providing markdown money and even allow them to return. Our online platform in Taobao operates well, in which we can sell the items returned by our retailers. However, the business is getting more and more difficult in China, and we are now facing heavy pressure on inventory. So our management board is thinking to reform our distribution channel. Maybe in the future, we just allow quantity-restricted returns or even do not allow any."

The LX had over 400 stores throughout China. Majority of retailers were large scale retailers and who also sold other fashion brands. When discussing how the LX selected the retailers, the general manager said that:

"Our retailers are sometimes introduced by good and reliable friends. As such, we are more confident to have them. However, we still have very strict requirement when we select the retailers in the specified location or region. We require our retailers who have experience in fashion retailing and healthy cash flow."

3.1.3.3.Summary

The LX was playing the role of the leader in its relationship with retailers. Although it had an MOQ requirement under the LX's MMP scheme, the markdown money was offered voluntarily, which was deemed as kind of "pull money" for the LX to trade with its retailers. Under such scheme, with sales data sharing, the retailers were more convinced to order more and meanwhile the markdown money helped the LX to reduce the leftovers to ship back. The benefit of such scheme had been confirmed by Krishnan et al. (2004) that the supplier's profit could be maximized if the supplier was able to access to the retailer's early-season demand data. There are several interesting insights as follows.

First, the economic circumstance had a significant impact on supply chain contract in the TC industry in China. It is well-known that Chinese economy was booming in the recent decade which led to a high consumption in the fashion products (Choi et al. 2008; Liu et al. 2011). To seek for a higher profit, Chinese fashion brand owners were more aggressive. They were willing to give benefits to their retailers and incentive them to be more cooperative. For example in the LX, the MMP scheme could help the retailers to incur a lower overstocking and out of stocking risk. If the scheme was conducted in the favorable economic season, it would not be a big burden to the LX. It is fine to adopt the MMP when market demand is high. However, potential risk and danger were hidden that such scheme would reduce the retailer's incentive to work hard when market demand was low. As such, the provision of markdown money would reduce the LX's profit margin and create a contract-induced moral hazard. Unfortunately, China economic was also influenced by the global financial tsunami in 2008. The fashion consumption dropped quickly and running a business in China was increasingly difficult. The LX was more risk-averse than before and it explained why the LX hesitated to continue promising returns.

In addition, the cultural factors such as power distance and collectivism could explain the behavior of Chinese firm in trading. First of all, the markdown money was a kind of LX's power which helped the LX to build up the leadership and better managed its retailers. The fashion brand owner in China usually played the role of the principal or leader, which could be explained by the principal-agent theory for contracting problems in supply chain management (Tsay et al. 1998, Lyer et al. 2005) and power distance in the cross-cultural study (Zhao et al. 2008). China national culture was characterized by high power distance, which implied an acceptance of power inequalities (Hofstede, 1984, 1991, 2001; Buckley et al. 2002). People expected decisions to be made by the more powerful party and would not feel comfortable otherwise (Randolph and Sashkin 2002). In China, power affected not only the leadership, but also the relationship (Zhao et al. 2008). Guanxi (relationship) was important in the business environment in China, and it was more desirable to associate with a powerful partner in China (Zhuang and Zhou 2004). The LX was more powerful than its retailers in the ability of developing the network, which implied strong guanxi. The LX thus had the leadership in its business. Moreover, the LX was quite causal and random to provide the markdown money during the season based on the inventory level, and the LX's retailers did believe that the LX could make the right decision. This revealed the meaning of relationships in a collectivism country like China, where Chinese people were more likely to depend on group-based decision and they emphasized group loyalty (Hofstede 1991).

3.2.Summary and Managerial Insights

The MMP was commonly adopted in the TC industry. After implementing the MMP, both the supplier and the retailer were more strategic and thoughtful. In this chapter, two case studies on the TC companies in the U.S.A. (the LC) and China (the LX) were conducted.

After making a comparison in the adoption of MMP between the investigated firms, the markdown money is deemed as a kind of "incentive (push) money" in the U.S.A. and "pull money" in China. One potential explanation was that China and the U.S.A. had huge difference in culture background and economic circumstance. Recall Hofstede's four cultural dimensions (Hofstede 1984), it had several interesting observations on the implementation of MMP in the TC industry between the U.S.A. and China from the cultural perspective. The case studies delivered important insights into both local and global supply chain governance across culturally diverse partners. They also provided a strong nationally cultural foundation to the understanding of strategic fit of supply chain management and its influence on firm performance.

First, supply chain contract design in the TC companies was influenced by power distance. Power was described as the influence of one party over the other (Ireland and Webb 2006). As in a relatively high degree of power distance country, the Chinese TC companies with a stronger bargaining power were more willing to manage the supply chain and offer the markdown money voluntarily to his retailers; whereas as in a relatively low degree of power distance country, the American TC companies with less strong bargaining power had to bargain with his retailers and showed their sense of fairness. As a result, the markdown money was asked to provide involuntarily. Power refers to the ability of a party in a relationship to hold and control distinctive knowledge, information and skills that are valuable to the other party (Cox 2001); whereas power also concerns a party's desire to be associated with another out of admiration for them (Zhao et al. 2008). This finding would also be supported by the work of Su and Zhang (2008) in which they suggested that a strong supplier should offer the markdown money to his retailer for obtaining a better business performance.

Second, collectivism and individualism affected the behavior of TC companies in supply chain contract management. Based on Pan and Zhang (2004)'s argument, the U.S.A. was strong in individualism, which implied that the Americans were more likely to look at their own interest to make decision and less likely to cooperate, whereas China was strong in collectivism, which meant the Chinese people were more likely to cooperate with others and cared more about loyalty to the group. This can explain the phenomenon in our case studies that the LC, the American TC company, preferred following strict rules in designing the MMP; whereas the LX, the Chinese TC firm, was quite causal and random to provide the markdown money during the season. The American firms believed that the formal contracts could ensure their own interests so that the partners tended to focus on the original goals and aspirations, whereas Chinese firms did not consider the contracts as seriously as the American counterparts. Instead, they preferred more dynamic contract and tended to pay more attention to relationships with their partners than contracts. This is also a way to understand why the Chinese firms loved to know their partners through "personal" introduction by their reliable friends.

Third, power distance and collectivism/individualism affected the position of supplier-retailer leadership in the U.S.A. and China. The practices of contract format were related to cultural factors, and the contract format with markdown money was a determinant factor for leadership. For example, a less formal contract on markdown money in China firm led to a stronger leadership in supplier side. The importance of leadership was emphasized in supply chain management. Ellram and Cooper (1990) indicated that a supply chain leader is like a channel captain in the marketing channels and played a key role in coordinating and overseeing the whole supply chain. It is well-known that if the supply chain is coordinated, naturally the performance of the whole supply chain arguably will be improved. To achieve this great performance, the TC companies in China, a high power distance and collectivism country, should undertake more activities that could enhance the local partners' trust and take more responsibility in the position of the leader. It was confirmed that the success of supply chain management was directly related to the presence of constructive leadership, which is capable of stimulating the cooperative behavior between participating firms (Schmitz et al. 1994). However, the cooperative behavior did necessarily need a close relationship being established.

Fourth, power distance and collectivism/individualism affected the behavior of supplier-retailer relationship (guanxi) in the U.S.A. and China. As a higher power distance and collectivism country, Chinese people cared more about guanxi, whereas people from a lower distance and individualism country like the U.S.A. did not. For Chinese TC companies, guanxi dominated all kinds of supply chain relationships. Guanxi was crucial for the success of Chinese companies, particularly for the business processes related supplier-buyer relationship. As a result, more flexibility with "human decisions" was critical to ensure success in using ad-hoc incentive and benefits for companies operating in China. However, the American TC companies emphasized the importance of contract and performance in supply chain, instead of relationship.

Undoubtedly, for the global TC business, understanding the business culture was critical for its long-term success. When trading with international business between countries like China and the U.S.A., mutual understanding from each other was extremely important. For example, the American TC firms, when they were entering the China market, should undertake more actions to develop long-term relationships with Chinese retailers. The firms should understand the culturally founded expectations of its global supply chain partners, and should work toward establishing relational norm governance strategies accordingly so that both parties can work smoothly. A cross-cultural adaptation was significant for firms to create the greatest likelihood of a successful cross-cultural buyer-supplier relationship. This had been confirmed that the long-term relationship was important for the success of supply chain on the basis of cross-cultural business circumstance (Cannon et al. 2010; Jia and Lamming 2013).

In short, this chapter provided many industrial practices of MMP adoption in the TC industry. It also provided the empirical evidence and motivation for the technical analyses in the next chapters.

4. The Coordination of TC Supply Chains with a Risk Averse Supplier under the Markdown Money Policy: An Analytical Study[9]

According to one of the important observations in the case studies conducted in Chapter 3, the supplier is nowadays more risk averse than before, which is also consistent with the industrial practices in the TC industry. For example, in the mainland China, hundreds of apparel manufacturers went bankrupt after the financial tsunami in 2008 simply because of their poor control of risk and cash flows (Yeung et al. 2012). In this chapter, a two-echelon supply chain with a risk-averse upstream supplier (e.g., a garment manufacturer) and a risk-neutral retailer selling a fashion product is considered in a single selling season. The product such as fashion apparel has a short life and is modeled as a newsvendor-type product. Our aim in this chapter is to analytically explore the supply chain contracting mechanism of the MMP[10] in the presence of a risk-averse supplier.

[9] The materials of Chapter 4 were consolidated and published in a journal paper: "Shen, B., T.M. Choi, Y. Wang, C.K.Y. Lo. The Coordination of Fashion Supply Chains with a Risk Averse Supplier by the Markdown Money Policy. *IEEE Transactions on Systems, Man, and Cybernetics - Systems*, 43, 266-276, 2013."

[10] The MMP is similar to the return policy, but the MMP does not require the physical return of leftover products and is commonly applied in the TC industry.

4.1.Notation

A summary of notation is listed in Table 4.1 for readers' reference.

Table 4.1 A summary of notation

Notation	*Meaning*
r	Retail price
c	Production cost
w	Wholesale price
b	Markdown price
v	Salvage value
k_S	Risk aversion threshold for the supplier
k_{SC}	Risk aversion threshold for the supply chain
EP	Expected Profit
SP	Standard Deviation of Profit
SC	Supply Chain
S	Supplier
R	Retailer
SCC	Supply Chain Coordination
MV	Mean-variance
MMP	Markdown Money Policy

4.2.Model Development

A two-echelon fashion supply chain selling a short-life fashion product with an upstream risk-averse manufacturer (termed as the supplier) and a downstream risk-neutral retailer is considered. To produce each product, the supplier incurs a unit production cost c. It sells the product to the retailer at a unit wholesale price w. During the selling season, the retailer sells the product to the consumer market at a unit retailing price r.

Under the MMP, the supplier grants the retailer a unit markdown (sponsor) price denoted by b, where $b < w$. At the end of the selling season, the leftover products can be cleared at a unit salvage value v. Assume that $b > v$. Thus, under the MMP, for each unit of the leftover inventory, the retailer gets a monetary unit value of b from the supplier while the supplier will finally receive a unit value of v from the retailer after the product is salvaged. Thus, the actual amount of money granted by the supplier to sponsor the retailer for each unit of the leftover is $b - v$. To avoid trivial cases, the model assumes that $r > w > v$, $w > c$, $c > v$ and $b \geq v$. That is,

$$r > w > \max(b, c) \geq \min(b, c) \geq v \geq 0. \tag{4.1}$$

The sequence of events for this two-echelon supply chain is as follows. First, the supplier announces his wholesale price w and markdown price b. The retailer then decides her ordering quantity q. Here, it considers a make-to-order supply chain in which the supplier produces exactly the amount (q) ordered by the retailer, which is a common practice in the fashion industry according to our industrial survey. The customer demand is random and denoted by a random variable x with a probability density function (p.d.f.) $f(x)$, and a corresponding cumulative density function (c.d.f.) $F(x)$. There exists a one-to-one mapping between $F(x)$ and its argument x. Denote the inverse function of $F(x)$ by $F^{-1}(x)$. Let subscripts S, R, SC represent Supplier, Retailer, and Supply Chain, respectively.

In the following, both the expected profit (EP) and the standard deviation of the profit (SP) for the supplier, the retailer and the whole supply chain, respectively are examined. The following list of notation is employed:

EP_R = EP of the retailer;

SP_R = SP of the retailer;

EP_S = EP of the supplier;

SP_S = SP of the supplier;

EP_{SC} = EP of the supply chain, and

SP_{SC} = SP of the supply chain.

Following the approach of Choi et al. (2008), (4.2) is defined,

$$\mathrm{var}(q-x)^{+} = \xi(q) = 2q\int_0^q F(x)dx - 2\int_0^q xF(x)dx - \left(\int_0^q F(x)dx\right)^2. \quad (4.2)$$

Then the EPs and SPs for all the parties can be derived and they are summarized in

Table 4.2.

Table 4.2. Profits, EPs and SPs of the supply chain, the retailer and the supplier

	Profit	*EP*	*SP*
Supply Chain	$(r-c)q \ -(r-v)(q-x)^{+}$.	$(r-c)q \ -(r-v)n(q)$.	$(r-v)\sqrt{\xi(q)}$.
Retailer	$(r-w)q-(r-b)(q-x)^{+}$.	$(r-w)q-(r-b)n(q)$.	$(r-b)\sqrt{\xi(q)}$.
Supplier	$(w-c)q-(b-v)(q-x)^{+}$.	$(w-c)q-(b-v)n(q)$.	$(b-v)\sqrt{\xi(q)}$.

Note that $n(q)=\int_0^q F(x)dx$ and all SPs in Table 4.2 are increasing functions of q as the first-order derivative of $\xi(q)$ with respect to q is non-negative (Choi et al. 2008).

In the following, the case where the supply chain's objective is to maximize the system-wide EP is considered. For this case, the optimal quantity q_{SC,EP^*} which maximizes the supply chain's EP can be derived by solving $dEP_{SC}(q)/dq=0$:

$$q_{SC,EP^*} = F^{-1}[(r-c)/(r-v)] \tag{4.3}$$

Next, if the supply chain's goal follows the MV objective, then the optimal supply chain quantity q_{SC,MV^*} can be derived by solving the following optimization problem (Choi et al. 2008):

$$\text{(P(SC))} \quad \max_{q} \quad EP_{SC}(q).$$

$$s.t. \quad SP_{SC}(q) \le k_{SC}.$$

where $k_{SC} \geq 0$. Here, k_{SC} is regarded as the risk aversion threshold for the whole supply chain. A smaller k_{SC} implies that the supply chain's tolerance towards SP is smaller, that is, the system decision maker is more conservative towards risk. It can be shown that there exists a unique optimal solution of q_{SC,MV^*}, and $q_{SC,MV^*} < q_{SC,EP^*}$ (see Choi et al. 2008 for more details.)

As for the retailer, for a given pair of the wholesale price w and markdown price b, the retailer will make her product ordering decision to maximize her own expected profit. The optimal ordering quantity q_{R,EP^*} can be found by solving $dEP_R(q)/dq = 0$ and

$$q_{R,EP^*}(b,w) = F^{-1}[(r-w)/(r-b)] \quad (4.4)$$

Equation (4.4) implies that if the markdown price b is higher, the retailer will be attracted to order more, whereas if the wholesale price w is higher, the retailer will be attracted to order less. Therefore, there exists a tradeoff between the markdown price b and the wholesale price w, and their relative value will affect the optimal reactive ordering decision of the retailer.

4.3.Supply Chain Coordination under the MMP: Analytical Results

In this section, the supplier's optimal decision on the MMP is discussed, which can help coordinate the whole supply chain under the objectives of either maximizing system-wide EP (a risk-neutral supply chain with an EP maximization objective) or maximizing the system-wide EP with a constraint on SP (a risk-averse supply chain with an MV objective). Thus, for each supply chain objective $l \in (EP, MV)$, the risk-averse supplier aims to find the optimal wholesale price w and markdown price b so as to maximize its own expected profit, subject to the constraint that the standard deviation of its own profit will be no larger than its risk tolerance level k_S (P.S.: the first constraint in Problem (P1)). Moreover, to achieve supply chain coordination (SCC), the supplier has to set the contract parameters in a way to ensure the retailer's optimal order quantity will be the same as that of the supply chain's, i.e. $q_{R,EP^*} = q_{SC,l^*}$. As a result, an equality constraint on quantities (the second constraint in Problem (P1)) is added to the optimization model. The specific optimization problem is hence given as follows.

$$
\begin{aligned}
\text{(P1)} \quad \max_{b_l, w_l} \quad & EP_S(q_{R,EP^*}(b_l, w_l)) \\
s.t. \quad & SP_S(q_{R,EP^*}(b_l, w_l)) \le k_S \\
& q_{R,EP^*}(b_l, w_l) = q_{SC,l^*} \\
& l \in (EP, MV),
\end{aligned}
$$

where (b_l, w_l) represents the pair of the markdown price and the wholesale price under the supply chain objective l where $l = EP \text{ or } MV$, and $k_S \geq 0$ is the risk tolerance threshold of the supplier which reflects the supplier's degree of risk aversion. (P.S.: A smaller k_S implies a smaller degree of risk tolerance towards SP, and hence a more risk averse supplier). Denote (b_l^* and w_l^*) as the optimal solution pair of (P1), where $l = EP \text{ or } MV$.

Theorem 4.1.

(a) If the supply chain's coordination objective is on maximizing the supply chain's EP, i.e. $l = EP$, then:

$$b_{EP}^* = \frac{k_S}{\sqrt{\xi(q_{SC,EP^*})}} + v, \quad w_{EP}^* = \frac{\left(\frac{k_S}{\sqrt{\xi(q_{SC,EP^*})}} + v\right)(r-c) + r(c-v)}{(r-v)}.$$

(b) If the supply chain coordination's objective follows the MV model (P(SC)), i.e. $l = MV$, then:

$$b_{MV}^* = \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} + v, \quad w_{MV}^* = r - \left(r - v - \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}}\right) F(q_{SC,MV^*}).$$

Based on Theorem 4.1, the supply chain can be coordinated when the supplier is risk averse and the retailer is risk neutral[11]. Then the following corollary is obtained.

Corollary 4.1. w_l^* *is increasing in* b_l^*, $\forall\, v \leq b_l^* < w_l^*$, $l \in (EP, MV)$.

[11] If both the supplier and the retailer are risk averse, MMP can achieve coordination under some cases only. In this chapter, our focus is on examining the impact of supplier's risk aversion. In order to obtain neat results, we assume the retailer is risk neutral.

Corollary 4.1 implies that when the supply chain is coordinated, the corresponding MMP will exhibit the property that the wholesale price is increasing in the markdown price. In other words, under the coordinating MMP: When the retailer wants to obtain a higher "markdown price protection" from the supplier, it also needs to pay the supplier a higher wholesale price.

Lemma 4.1. *For a fixed* k_{SC} *, (a) both* w_{MV}^* *and* b_{MV}^* *are increasing in* k_S *,* $\forall\, v \le b_{MV}^* < w_{MV}^*$ *, (b)* $EP_S(q_{SC,MV^*})$ *is increasing in* k_S *, but* $EP_R(q_{SC,MV^*})$ *is decreasing in* k_S *.*

Lemma 4.1 shows that the supplier's attitude towards risk does affect the optimal coordinating MMP. If the supplier is less risk-averse (larger k_S), then he will offer a higher wholesale price w_{MV}^* as well as a higher markdown price b_{MV}^*. Lemma 4.1 also indicates that under the MV supply chain coordination framework, the resulting expected profit for the supplier $EP_S(q_{SC,MV^*})$ increases in the supplier's risk tolerance threshold k_S, whereas the resulting expected profit for the retailer $EP_R(q_{SC,MV^*})$ decreases in it.

Lemma 4.2. *For a fixed* k_{SC}*, the relative difference between the optimal wholesale price and the markdown price (* $w_{MV}^* - b_{MV}^*$ *) is decreasing in* k_S *.*

Lemma 4.2 implies that if the supplier's tolerance level towards risk is reduced (a smaller k_S), then the supplier will set the MMP in such a way that the relative difference between the optimal wholesale price and the markdown price ($w^*_{MV} - b^*_{MV}$) is larger. It is very intuitive because if the supplier has a lower risk tolerance level (a smaller k_S) and is hence more risk averse, he will behave as a less generous supplier by charging the retailer a higher optimal wholesale price or granting the retailer a lower optimal markdown price. Consequently, the respective difference between the optimal wholesale price and optimal markdown price, i.e. ($w^*_{MV} - b^*_{MV}$), is larger.

Proposition 4.1. *For a fixed* k_S , $EP_S[q_{SC,MV^*}(b^*_{MV})]$ *is increasing in* b^*_{MV} , $\forall\, v \le b^*_{MV} < w^*_{MV}$.

Proposition 4.1 shows that if the supplier' risk aversion threshold (k_S) is fixed, his EP actually increases if the optimal markdown price b^*_{MV} is higher. It is interesting to find that when a risk averse supplier sets the parameters of MMP appropriately to coordinate the supply chain, he actually can enjoy a higher EP by offering a higher markdown price. One potential reason is that a higher markdown price may motivate the retailer to order more, which in turn benefits the supplier. This is especially true because the supply chain is coordinated.

Proposition 4.2. *For any given* k_S *and* $k_{SC} \le SP_{SC}(q_{SC,EP*})$, *(a) the optimal markdown* b^*_{MV} *is non-increasing in* k_{SC} $\forall\, v \le b^*_{MV} < w^*_{MV}$; *(b)* $SP_R(q_{SC,MV^*})$ *is non-decreasing in* k_{SC} .

The condition $k_{SC} \le EP_{SC}(q_{SC,EP*})$ implies that the constraint on risk must be binding (cf. the constraint in (P(SC)). Notice from Proposition 4.2a that when k_S is fixed, if the risk tolerance level of the entire supply chain decreases (a smaller k_{SC}), the supplier will set a higher optimal markdown price b^*_{MV}. Proposition 4.2b also shows that a higher risk level for the entire supply chain will lead to a larger standard deviation of the retailer's profit $SP_R(q_{SC,MV^*})$.

Denote the profit's coefficient of variation for the supply chain agent i by Δ_i, and define it as follows.

$$\frac{SP_i(q_{SC,MV^*})}{EP_i(q_{SC,MV^*})} = \Delta_i, \quad i \in (R, S, SC).$$

Here Δ_i measures party i's profit uncertainty under the MV framework. Notice that the profit's coefficient of variation indicates the level of risk per unit of expected return. Cachon (2004) stated that a lower value of the profit's coefficient of variation would imply a higher supply chain performance. Therefore, it is meaningful to use the profit's coefficient of variation as an analytical measure to evaluate the performance of the entire supply chain and its agents. Proposition 4.3 shows an important analytical result.

Proposition 4.3. *The supply chain's and the retailer's profit's coefficients of variation, Δ_{SC} and Δ_R, are dependent of k_{SC}, but independent of k_S.*

Proposition 4.3 shows that setting an appropriate level of supply chain risk tolerance level has a direct impact not only on the supply chain's profit's coefficient of variation (Δ_{SC}), but also on the retailer's profit's coefficient of variation (Δ_R). It is indeed intuitive that the supply chain's profit's coefficient of variation (Δ_{SC}) depends on k_{SC} as this threshold controls the maximum acceptable level of profit uncertainty in a supply chain. However, it is surprising to observe from Proposition 4.3 that the retailer's profit's coefficient of variation (Δ_R) is independent of k_S. Recall from Lemma 4.1 (b) that EP_R is decreasing in k_S. However, the result here tells us that the risk tolerance level of the supplier (k_S) cannot affect the retailer's profit's coefficient of variation (Δ_R). In other words, k_S does not affect the retailer's and the entire supply chain's performances in terms of the respective risk per unit of return. This finding is interesting because no matter how risk averse the supplier is, provided that it adopts MMP to coordinate the supply chain, the resulting supply chain's profit coefficient of variation remains the same. Moreover, the retailer's profit coefficient of variation also remains the same. This implies the versatility of applying MMP for achieving a consistently efficient supply chain.

4.4. Numerical Analysis: Real Data Studies

This section proceeds to employ two real TC companies' data (given to us by managers of the respective companies during a questionnaire survey) to study how the coordinating MMP affects supply chain's performance in the real business world. For confidentiality issue, the cost-revenue data values are scaled while they still well-reflect the real market situation. This scaling does not affect the quality of any research finding. For the demand distribution details, they are the best estimates collected from the managers of the respective companies. Example (a) studies 'SH', which is a supplier of fashion products, in which the unit product cost $c = 160$ and the unit salvage price $v = 20$; the retailer sets her unit product price $r = 500$. The unit markdown price b and the unit wholesale price w are determined by SH with respect to his objective. The order quantity q is determined by the retailer. Market demand for the product is estimated to be normally distributed with mean 100 and variance 30^2. Example (b) refers to 'CC', which is a children's clothing supplier, in which the unit product cost $c = 160$ and the unit salvage price $v = 60$; the retailer sets the product's unit selling price $r = 400$. Market demand for the product is normally distributed with mean 150 and variance 50^2. The parameter values from these two cases into the analytical model with MMP for analysis are incorporated.

Table 4.3 and Table 4.4 represent the numerical analyses for SH and CC, respectively. For both companies, notice that in Case 1 of Table 4.3 and Table 4.4: When $k_{SC} \to \infty$ and $k_S \to \infty$, the supplier obtains all the expected profit and the standard deviation of profit in the whole supply chain. Case 2 in Table 4.3 and Table 4.4 refers to a situation under which only k_S is active and hence it is effective to constrain the supplier's SP. In Case 3 of Table 4.3 and Table 4.4, k_{SC} controls the supply chain's SP while the constraint on supplier is non-binding, namely he is risk neutral. This could be explained by the scenario in which a risk averse third party supply chain planner is present who aims at achieving its MV supply chain goal by coordinating both the risk neutral supplier and the risk neutral retailer via the MMP. Therefore, Case 3 provides the insights when this scenario happens. From the numerical results, it is found that the optimal markdown price (b_l^*) is influenced by the supply chain risk tolerance threshold k_{SC}. Comparing the EPs and SPs of "Case 1 against Case 2", "Case 4 against Case 5", and "Case 5 against Case 6", the percentage changes of the EPs and SPs are shown in Table 4.3 and Table 4.4.

Table 4.3. The numerical analyses on SH

Supply chain coordination is achieved by the markdown price under our MV approach											
Case	k_{SC}	k_S	$q_{SC,l*}$	b_l^*	w_l^*	EP_{SC}	SP_{SC}	EP_S	SP_S	EP_R	SP_R
1	∞	∞	115.7	500	500	29291	10705	29051	10705	0	0
2	∞	4000	115.7	199	345	29291	10705	17671	4000	11620	6705
3	8500	∞	100.7	500	500	28497	8500	28497	8500	0	0
4	7500	4000	94.6	276	403	27541	7500	20616	4000	6925	3500
5	7500	3500	94.6	244	390	27541	7500	19627	3500	7914	4000
6	7000	3500	91.5	260	406	27177	7000	20612	3500	6565	3500

The percentage decrease comparisons of EP and SP			
		% decrease in EP	% decrease in SP
Case 1 VS Case 2	Supply chain	0	0
	Supplier	64.3	167.6
	Retailer	-100	-100
Case 4 VS Case 5	Supply chain	0	0
	Supplier	5.0	14.2
	Retailer	-12.4	-12.5
Case 5 VS Case 6	Supply chain	1.3	7.1
	Supplier	4.7	0
	Retailer	20.5	14.2

Table 4.4. The numerical analyses on CC

Supply chain coordination is achieved by the markdown price under our MV approach

Case	k_{SC}	k_S	q_{SC,l^*}	b_l^*	w_l^*	EP_{SC}	SP_{SC}	EP_S	SP_S	EP_R	SP_R
1	∞	∞	176.2	400	400	30150	12737.4	30150	12737.4	0	0
2	∞	3500	176.2	153.4	271.0	30150	12737.4	16235.7	3500	13914.3	9237.4
3	10000	∞	151	400	400	29293.1	10000	29293.1	10000	0	0
4	9000	3500	142.4	192.2	308.6	28614.2	9000	19006.4	3500	9607.8	5500
5	9000	3000	142.4	173.3	300.3	28614.2	9000	18133	3000	10481.2	6000
6	8000	3000	133.9	187.5	320.5	27748.8	8000	19857.6	3000	7891.2	5000

The percentage decrease comparisons of EP and SP			
		% decrease in EP	% decrease in SP
Case 1 VS Case 2	Supply chain	0	0
	Supplier	85.7	263.9
	Retailer	-100	-100
Case 4 VS Case 5	Supply chain	0	0
	Supplier	4.8	16.6
	Retailer	-8.3	-8.3
Case 5 VS Case 6	Supply chain	3.1	12.5
	Supplier	-8.6	0
	Retailer	32.8	20

In Table 4.3 and Table 4.4, the numerical analyses on SH and CC also indicate that if k_S is fixed, a smaller value of k_{SC} will lead to a larger value of the optimal markdown price (b_l^*) as well as a larger value of the supplier's EP. For the supplier, setting a relatively high markdown price (b_l^*) will attract the retailer to order more (until achieving the optimal order quantity (q_{SC,l^*})). Another observation from Table 4.3 and Table 4.4 is that if the value of k_{SC} increases, the optimal order quantity (q_{SC,l^*}) will tend to increase.

The numerical examples show that by sacrificing a certain amount of EP, both SH and CC can yield a substantial percentage reduction in the SP (and hence risk). In other words, both companies will encounter substantially lower risk if they employ the analytical model proposed in this chapter. It is hence wise to include the risk consideration in the analysis.

In addition, from our discussions with the companies, both SH and CC have used (and are still implementing) MMP. For SH, the unit markdown price $b = 135$ and the unit wholesale price $w = 270$; for CC, the unit markdown price is $b = 172$ and the unit wholesale price is $w = 230$. These two companies' performances with respect to their current MMP parameters are hence explored in the following.

Table 4.5. Profit's coefficient of variation comparison for SH

(A) EPs, SPs, and Profit's coefficients of variation based on the markdown price b and wholesale price w current set by the SH Company (current business Practice)

q	b	w	EP_{SC}	SP_{SC}	EP_S	SP_S	EP_R	SP_R
114.4	135	270	29047	11299	10224	2707	18823	8592

$\triangle_{SC}$	$\triangle_S$	$\triangle_R$
0.38	0.26	0.45

(B) The SH Company: Profit's coefficient of variation under the theoretical SCC model

Case	EP_{SC}	SP_{SC}	$\triangle_{SC}$	EP_S	SP_S	$\triangle_S$	EP_R	SP_R	$\triangle_R$
1.1	29051	10705	0.36	29051	10705	0.36	0	0	0
2.1	29291	10705	0.36	19796	4500	0.22	9495	6205	0.65
3.1	29291	10705	0.36	17671	4000	0.22	11620	6705	0.57
4.1	29291	10705	0.36	15547	3500	0.22	13744	7205	0.52
5.1	29291	10705	0.36	13422	3000	0.22	15869	7705	0.48
6.1	29291	10705	0.36	9173	2000	0.21	20118	8705	0.43
1.2	28497	8500	0.29	28497	8500	0.29	0	0	0
2.2	28497	8500	0.29	19618	4500	0.22	8879	4000	0.45
3.2	28497	8500	0.29	18507	4000	0.21	9990	4500	0.45
4.2	28497	8500	0.29	17397	3500	0.20	11100	5000	0.45
5.2	28497	8500	0.29	16285	3000	0.18	12212	5500	0.45
6.2	28497	8500	0.29	11406	2000	0.17	14433	6500	0.45
1.3	27541	7500	0.27	27541	7500	0.27	0	0	0
2.3	27541	7500	0.27	21605	4500	0.20	5936	3000	0.50
3.3	27541	7500	0.27	20616	4000	0.19	6925	3500	0.50
4.3	27541	7500	0.27	19627	3500	0.17	7914	4000	0.50
5.3	27541	7500	0.27	18637	3000	0.16	8904	4500	0.50
6.3	27541	7500	0.27	16659	2000	0.12	10882	5500	0.50
1.4	27177	7000	0.25	27177	7000	0.25	0	0	0

2.4	27177	7000	0.25	22488	4500	0.20	4689	2500	0.53
3.4	27177	7000	0.25	21550	4000	0.18	5627	3000	0.53
4.4	27177	7000	0.25	20612	3500	0.16	6565	3500	0.53
5.4	27177	7000	0.25	19674	3000	0.15	7503	4000	0.53
6.4	27177	7000	0.25	17798	2000	0.11	9379	5000	0.53
1.5	26706	6500	0.24	26706	6500	0.24	0	0	0
2.5	26706	6500	0.24	23152	4500	0.19	3554	2000	0.56
3.5	26706	6500	0.24	22263	4000	0.17	4443	2500	0.56
4.5	26706	6500	0.24	21375	3500	0.16	5331	3000	0.56
5.5	26706	6500	0.24	20486	3000	0.14	6220	3500	0.56
6.5	26706	6500	0.24	18709	2000	0.10	7997	4500	0.56

Table 4.6. Profit's coefficient of variation comparison for CC

(A) EPs, SPs, and Profit's coefficients of variation based on the markdown price b and wholesale price w current set by the CC Company (current business practice)

q	b	w	EP_{SC}	SP_{SC}	EP_S	SP_S	EP_R	SP_R
183.7	172	230	30100	13433	8251	4425	21849	9008

$\triangle_{SC}$	$\triangle_S$	$\triangle_R$
0.44	0.53	0.41

(B) CC Company: Profit's coefficient of variation under the theoretical SCC model

Case	EP_{SC}	SP_{SC}	$\triangle_{SC}$	EP_S	SP_S	$\triangle_S$	EP_R	SP_R	$\triangle_R$
1.1	30150	12737.4	0.42	30150	12737.4	0.42	0	0	0
1.2	30150	12737.4	0.42	18110.8	4000	0.22	12039.2	8737.4	0.73
1.3	30150	12737.4	0.42	16235.7	3500	0.22	13914.3	9237.4	0.66
1.4	30150	12737.4	0.42	14360.5	3000	0.21	15789.5	9737.4	0.62
1.5	30150	12737.4	0.42	12485.3	2500	0.20	17664.7	10237.4	0.58
1.6	30150	12737.4	0.42	10610.1	2000	0.19	19539.9	10737.4	0.55
2.1	29780.6	11000	0.36	29780.6	11000	0.37	0	0	0
2.2	29780.6	11000	0.36	15261.4	4000	0.26	14519.2	7000	0.48
2.3	29780.6	11000	0.36	14224.3	3500	0.25	15556.3	7500	0.48

2.4	29780.6	11000	0.36	13187.1	3000	0.23	16593.5	8000	0.48
2.5	29780.6	11000	0.36	12150.0	2500	0.21	17630.6	8500	0.48
2.6	29780.6	11000	0.36	11112.9	2000	0.18	18667.7	9000	0.48
3.1	29293.1	10000	0.34	29293.1	10000	0.34	0	0	0
3.2	29293.1	10000	0.34	17812.8	4000	0.22	11480.3	6000	0.52
3.3	29293.1	10000	0.34	16856.2	3500	0.21	12436.9	6500	0.52
3.4	29293.1	10000	0.34	15899.4	3000	0.19	13393.7	7000	0.52
3.5	29293.1	10000	0.34	14942.7	2500	0.17	14350.4	7500	0.52
3.6	29293.1	10000	0.34	13986.0	2000	0.14	15307.1	8000	0.52
4.1	28614.2	9000	0.31	28614.2	9000	0.31	0	0	0.57
4.2	28614.2	9000	0.31	19879.8	4000	0.20	8734.4	5000	0.57
4.3	28614.2	9000	0.31	19006.4	3500	0.18	9607.8	5500	0.57
4.4	28614.2	9000	0.31	18133	3000	0.17	10481.2	6000	0.57
4.5	28614.2	9000	0.31	17259.5	2500	0.14	11354.7	6500	0.57
4.6	28614.2	9000	0.31	16386.1	2000	0.12	12228.1	7000	0.57
5.1	27748.8	8000	0.28	27748.8	8000	0.29	0	0	0.63
5.2	27748.8	8000	0.28	21432.9	4000	0.19	6312.9	4000	0.63
5.3	27748.8	8000	0.28	20646.7	3500	0.17	7102.1	4500	0.63
5.4	27748.8	8000	0.28	19857.6	3000	0.15	7891.2	5000	0.63
5.5	27748.8	8000	0.28	19068.5	2500	0.13	8680.3	5500	0.63
5.6	27748.8	8000	0.28	18279.4	2000	0.11	9469.4	6000	0.63

Table 4.5 and Table 4.6 respectively demonstrate that the profit's coefficients of variation of SH and CC with different levels of k_S and k_{SC} with respect to their current business practices. Notice that a smaller profit's coefficient of variation implies a better risk-profit tradeoff. From Table 4.5 and Table 4.6, the coordinating MMP approach yields lower supplier's and the supply chain's profit coefficients of

variation (Δ_{SC} and Δ_S) than the MMP currently adopted by these two companies. Therefore, if both SH and CC operate according to our coordinating MMP approach, their performances will be improved. Moreover, the entire corresponding supply chain will be more efficient. Table 4.7 presents the sensitivity analysis to further illustrate how the risk tolerance levels affect the optimal contract parameters in the coordinating MMP as well as the respective performance of the supplier, the retailer, and the whole supply chain.

Table 4.7. Sensitivity analysis (with respect to k_S and k_{SC})

(Notation: +Increases; - Decreases; X No Change)

When k_{SC} is fixed, the effect brought by increasing k_S							
w_l^*	b_l^*	EP_S	EP_R	EP_{SC}	SP_S	SP_R	SP_{SC}
+	+	+	−	×	+	−	×
When k_S is fixed, the effect brought by increasing k_{SC}							
w_l^*	b_l^*	EP_S	EP_R	EP_{SC}	SP_S	SP_R	SP_{SC}
−	−	−	+	+	×	+	+

4.5. Managerial Implications and Conclusion

In this chapter, a two-echelon fashion supply chain with the MMP via an MV framework was explored. The case when the supplier is risk-averse was considered and the detailed mechanisms for achieving supply chain coordination were then derived. Important features of the MMP were revealed. This chapter produced some key insights and implications from the analysis in the following.

1. *The impact of the optimal markdown price* b_{MV}^**:* The optimal markdown price (b_{MV}^*) affects the expected profit share and the risk share between the supplier and the retailer in the supply chain. When the supply chain's risk tolerance level (k_{SC}) is fixed: If the supplier is less risk-averse (i.e. with a larger k_S), a higher optimal markdown price (b_{MV}^*) will be offered to the retailer. When the supplier's risk level (k_S) is fixed: If the supplier sets a higher value of the optimal markdown price (b_{MV}^*), the retailer will order a larger quantity and the supplier's expected profit (EP_S) will also be higher. Moreover, Corollary 4.1 shows that when the supply chain is coordinated, the corresponding MMP will exhibit the property that the wholesale price is increasing in the markdown price. In other words, under the coordinating MMP: If the retailer wants to obtain a higher "markdown price protection" from the supplier, she will also need to pay the supplier a higher wholesale price. From Proposition 4.1, an interesting finding is

that when a risk averse supplier sets the parameters of MMP appropriately to coordinate the supply chain, it actually can also enjoy a higher expected profit by offering a higher markdown price. One potential reason is that a higher markdown price will attract the retailer to order more, which in turn benefits the supplier.

2. *The supply chain risk threshold* k_{SC}: If k_S is fixed and $k_{SC} \leq EP_{SC}(q_{SC,EP*})$, the supply chain's risk tolerance threshold will affect the optimal markdown price b_{MV}^* and the retailer's standard deviation of profit. A higher k_{SC} leads to a lower markdown price b_{MV}^*. In addition, a higher k_{SC} implies that the retailer has a larger standard deviation of profit SP_R. These results show how the supply chain's objective (with respect to risk tolerance level) affects the retailer under the coordinating MMP.

3. *The supplier risk threshold* k_S*:* If k_{SC} is fixed, the supplier's risk tolerance threshold k_S will affect the value of the optimal markdown price b_{MV}^*. A higher k_S implies that the supplier sets a higher value of the optimal markdown price b_{MV}^* and receives a larger EP, but it leads to a smaller retailer's EP. As a result, it is interesting to note that the retailer will make less expected profit under the coordinating MMP if the supplier is risk averse (has a higher k_S). Moreover, from Lemma 4.2, it is found that if the supplier is more risk averse (i.e., has a smaller k_S), he will tend to charge a higher optimal wholesale price or grant a lower optimal

markdown price. Consequently, the respective difference between the optimal wholesale price and optimal markdown price, i.e. ($w_{MV}^{*} - b_{MV}^{*}$), will also be larger (and hence the supplier will be less "generous" to the retailer).

4. *Profit's coefficient of variations (Δ_i):* It is interesting to note that the profit's coefficient of variations for the retailer and the entire supply chain are independent of the supplier's risk tolerance level (k_S), but dependent of the supply chain's risk tolerance level (k_{SC}). In other words, when measuring the performance by the profit's coefficient of variation (i.e., the level of risk per unit of expected profit), the supplier's risk tolerance level (k_S) does not affect the retailer's performance and the entire supply chain's performance. However, the supply chain's risk tolerance level (k_{SC}) does have a direct impact on the retailer's and the supply chain's performances. This finding implies the versatility of applying MMP for achieving a consistently efficient supply chain.
5. *Impacts on the manufacturer and the fabric supplier:* In the TC industry, the supplier is able to first set the markdown price and the wholesale price, and then the retailer reacts by deciding the optimal ordering quantity. Our analytical coordinating MMP model can be employed to assist the supplier in making more accurate decisions. From the real data studies conducted above, it provides the solid evidence that the supplier and the entire supply chain will be more efficient

under a properly designed MMP. The amounts of improvement as compared to the current practices (parameters) adopted by the two companies under studies are substantial and remarkable. Hence, there is no doubt that our proposed MMP is implementable and significant to enhance the fashion supply chain's performance.

5. The Effect of Self-Serving Fairness Concerns on a Supply Chain with an MMP: An Experimental Study

According to the observations in case studies in Chapter 3, TC companies are primarily driven by the desire to earn at least their fair share. In a profit-maximization environment, supply chain parties often possess their own MPSR; that is, each party sought to capture a certain percentage of the whole supply chain profit. If the profits were below this percentage, the party might not have incentive to join the supply chain.

In this chapter, based on this observation above, a two-echelon supply chain in which the retailer (she) is self-serving and holds an MPSR concern is considered. The contract between the supplier (he) and the retailer is an MMP, which is widely adopted in the fashion industry.

In this chapter, a controlled laboratory experiment is employed to investigate how retailers' concerns about self-serving fairness affect the performance of the coordinating MMP and the TC supply chain. The TC supply chain follows a classic newsvendor setting with a highly fashionable product in which the supplier, as a Stackelberg leader, offers the MMP, and the retailer decides whether to take it or leave it according to her MPSR concern. Naturally, the retailer is more likely to accept a contract if her MPSR is low. In our experiment, the role of the supplier is played by human subjects who are practitioners in the fashion industry. A controlled laboratory setting is employed which is designed to conform to the assumptions of the contract model. To ensure that the MPSR concept is fully implemented by the retailer, the role of the retailer is played by a computer.

5.1.Notation

A summary of notation is listed in Table 5.1 for readers' reference.

Table 5.1 A summary of notation

Notation	*Meaning*
r	Retail price
c	Production cost
w	Wholesale price
b	Markdown price
v	Salvage value
λ	Markdown price ratio
k	Retailer's MPSR concern
B	Upper bound of uniform distribution
EP	Expected Profit
SP	Standard Deviation of Profit
SC	Supply Chain
S	Supplier
R	Retailer
SCC	Supply Chain Coordination
MMP	Markdown Money Policy

5.2.Analytical Background

In this section, the theoretical results for a scenario are presented, in which both the supplier and the retailer maximize their respective expected profits, subject to the retailer's MPSR concern under an MMP. In this scenario, the market demand x follows a uniform distribution $U[0,B]$. Denote r as the exogenous market retail price, c the supplier's unit production cost, and q the retailer's order quantity. Before the selling season, the supplier offers the retailer an MMP with a wholesale price w and a markdown price *b*. At the end of the selling season, the leftover inventories are returned to the supplier and the retailer receives the markdown price *b* for each unit of unsold products[12]. To avoid trivial cases, it is required that $r > w > \max(b,c) \geq \min(b,c) > 0$ and assumed that $b = \lambda w$, where λ is a constant[13] markdown price ratio such that $\lambda \in (0,1]$. In the next step the retailer decides whether to take the contract or not by following a two-stage decision process. In the first stage, given the MMP, the retailer decides what optimal order quantity will maximize her expected profit. In the second stage, the retailer checks whether the maximum achievable expected profit fulfills her MPSR requirement. Specifically,

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[12] The salvage value is assumed to be zero for the sake of simplicity. Notice that this assumption is rather common in the literature of behavioral supply chain management (Katok and Wu 2009, Kalkanci et al. 2011; Haruvy et al. 2012).

[13] Our fashion industry survey suggests that the markdown price is usually a fixed percentage of the wholesale price in this industry.

if her expected profit as a percentage of the supply chain profit is smaller than her MPSR, she decides to reject the contract and there is no business afterwards; if her expected profit as a percentage of the supply chain profit is equal to or above her MPSR, she accepts the contract and orders the optimal quantity. For ease of notation, subscripts *S*, *R*, and *SC* denote the supplier, retailer, and supply chain, respectively. The above problem is solved by backward induction.

5.2.1. The Retailer's Ordering and Contract Acceptance Decision

The retailer's ordering and contract acceptance decision is firstly solved. Given an MMP $\{w, \lambda w\}$ and an order quantity q, the expected profits of the retailer, the supplier, and the supply chain are, respectively,

$$E\pi_R(q) = (r-w)q - (r-\lambda w)q^2/2B, \tag{5.1}$$

$$E\pi_S(q) = (w-c)q - \lambda w q^2/2B, \text{ and} \tag{5.2}$$

$$E\pi_{SC}(q) = E\pi_R(q) + E\pi_S(q) = (r-c)q - rq^2/2B. \tag{5.3}$$

It can be easily shown that $E\pi_R(q)$ is strictly concave in q and that the retailer's optimal order quantity, when she has no MPSR concern, would be

$$\hat{q}_R(w,\lambda) = \arg_q\{dE\pi_R(q)/dq = 0\} = (r-w)B/(r-\lambda w). \tag{5.4}$$

Let $k \in [0,1]$ be the MPSR required by the retailer and denote $q_R^*(k|w,\lambda)$ as her corresponding optimal order quantity. The following Theorem 5.1 then provides a simple rule for the MPSR-concerned retailer deciding whether she should accept the MMP and what the corresponding optimal order quantity should be.

Theorem 5.1. *Let*

$$\Delta_H(k,\lambda) = \left[k[r-2\lambda(r-c)] + (1-\lambda)r\right]^2 + 8k\lambda r(1-\lambda)(r-c) \quad , \quad \textit{and} \quad (5.5)$$

$$w_{CP}(k) = \frac{1}{2\lambda}\left[(1+\lambda)r + k[r-2\lambda(r-c)] - \sqrt{\Delta_H(k,\lambda)}\right], \textit{ then} \quad (5.6)$$

(a) $c < w_{CP}(k) < r$ *; (b) the retailer accepts the MMP if and only if (iff)* $w \le w_{CP}$ *; and (c) the optimal order quantity of the retailer with an MPSR concern parameter k is*

$$q_R^*(k|w,\lambda) = \begin{cases} \hat{q}_R(w,\lambda) = (r-w)B/(r-\lambda w) & \textit{if} \quad w \le w_{CP}(k) \\ 0 & \textit{if} \quad w > w_{CP}(k) \end{cases}.$$

Theorem 5.1 indicates that $w_{CP}(k)$ is the maximum wholesale price that the retailer will accept in the contract when her required MPSR equals k. However, once the retailer accepts the contract, she will order as if she has no MPSR concern. In the rest of the study, $w_{CP}(k)$ is referred as the *MPSR-dependent threshold wholesale price*.

5.2.2. The Supplier's Pricing Decision

Anticipating the retailer's ordering decision, the supplier decides on a wholesale price that maximizes his expected profit, subject to the retailer's acceptance of the contract. As a rational decision maker, the supplier should also ensure that satisfying the retailer's requirement will not lead to a negative profit. In other words, his problem becomes

$$\underset{w}{Max}\, E\pi_S(w) = E\pi_S[q_R^*(k|w,\lambda)]$$

$$= (r-w)B[2(w-c)(r-\lambda w) - \lambda w(r-w)]/2(r-\lambda w)^2$$

$$\text{s.t.} \quad w \le w_{CP}(k), \tag{5.7}$$

$$E\pi_S(w) \ge 0, \tag{5.8}$$

where inequality (5.7) represents the retailer's contract acceptance constraint (from Theorem 5.1), and inequality (5.8) represents the supplier's participation constraint.

Lemma 5.1. *Let*

$$w_S^- = \frac{1}{2\lambda}[(2r - \lambda r + 2\lambda c) - \sqrt{4(1-\lambda)r^2 + \lambda^2(r-2c)^2}], \textit{ then} \tag{5.9}$$

(a) $c < w_S^- < r$ *; (b) if* $w_{CP}(k) < w_S^-$*, the supplier should not offer any MMP to the MPSR-concerned retailer; and (c) if* $w_{CP}(k) \ge w_S^-$*, the feasible range of the wholesale price w is* $w_S^- \le w \le w_{CP}(k)$.

Lemma 5.1 shows that if the MPSR-dependent threshold wholesale price (i.e., $w_{CP}(k)$) is too low, the supplier should not do business with the retailer, as his expected profit will become negative. In addition, Lemma 5.1 also gives the feasible range of the wholesale price that the supplier could expect the retailer to accept. The following analysis focuses on a case in which $w_{CP}(k) \geq w_S^-$ and the supplier offers the MMP. As such, the supplier's optimal wholesale price is derived as follows.

The first derivative of $E\pi_S(w)$ with respect to w is

$$\frac{dE\pi_S(w)}{dw} = \frac{(r-w)B}{2(r-\lambda w)^2}[2r - \lambda(r+w)] - \frac{(1-\lambda)rB}{(r-\lambda w)^3}\{w[r-\lambda(r-c)] - cr\}. \qquad (5.10)$$

Lemma 5.2. *Let* $\overline{w} = 2r(\lambda r - r + \lambda c)/\lambda(r - \lambda r + 2\lambda c)$, *then (a)* $d^2 E\pi_S(w)/dw^2 < 0$ *iff* $w > \max\{\overline{w}, 0\}$; *and (b) a sufficient condition for* $E\pi_S(w)$ *to be concave is* $\lambda < r/(r+c)$.

The above Lemma 5.2 provides a condition $\lambda < r/(r+c)$ that guarantees the concavity of the supplier's expected profit function. Under this condition, when the markdown price ratio λ is sufficiently small, the supplier's expected profit function is always strictly concave and there exists a unique optimal wholesale price. In reality, the unit retail price r is usually much greater than the unit production cost c, resulting in a large value of $r/(r+c)$. Thus the condition $\lambda < r/(r+c)$ can be easily satisfied, particularly as $r > c$ and $r/(r+c) > r/2r = 0.5$. Therefore, when $\lambda \leq 0.5$, the supplier's expected profit function is always strictly concave in w. Theorem 5.2 gives the optimal pricing decision of the supplier.

Theorem 5.2. *Assume that* $\lambda < r/(r+c)$ *and let* $\hat{w}_S = \arg_w\{dE\pi_S(w)/dw = 0\}$, *then*

(a) if $\hat{w}_S < w_S^-$, *where* w_S^- *is defined as in (9), the supplier should not offer any contract to the MPSR-concerned retailer; and (b) if* $\hat{w}_S \geq w_S^-$, *the optimal wholesale price that the supplier should offer to the MPSR-concerned retailer is*

$$w_S^* = \begin{cases} \hat{w}_S & \text{if } \ w_S^- \leq \hat{w}_S < w_{CP}(k) \\ w_{CP}(k) & \text{if } \ \hat{w}_S \geq w_{CP}(k) \end{cases} . \qquad (5.11)$$

5.2.3. Channel Coordination with an MPSR-concerned Retailer

In this section, whether channel coordination[14] is feasible in a supply chain with an MPSR-concerned retailer under an MMP is explored. From (5.3), the optimal order quantity that maximizes the supply chain's expected profit can be derived as $q_{SC}^* = (r-c)B/r$. For a supply chain to achieve coordination, it needs to fulfill $q_R^*(k|w,\lambda) = q_{SC}^*$. The corresponding wholesale price that satisfies this equation is

$$\hat{w}_{SC} = cr/(r - \lambda r + \lambda c) . \qquad (5.12)$$

For $\hat{w}_{SC}$ to be the feasible optimal wholesale price, it needs to satisfy the retailer's acceptance constraint, that is, $\hat{w}_{SC} \leq w_{CP}(k)$. The following Theorem 5.3 confirms such feasibility when the retailer's MPSR is sufficiently small.

Theorem 5.3. *Let* $\hat{k} = (1-\lambda)r/(r - \lambda r + \lambda c)$ *and assume that* $\lambda \leq 1/2$, *then channel*

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[14] In this chapter, channel coordination is defined as the one in which the supply chain's expected profit is maximized. Here the supplier is the coordinator and we do not pay attention to the subsequent expected profit he would attain when the supply chain is coordinated.

coordination is feasible iff $k < \hat{k}$*, and the coordinating wholesale price is given by* $w^*_{SC} = \hat{w}_{SC}$.

Next numerical studies are conducted to illustrate how the retailer's MPSR, k, affects the MPSR-dependent threshold wholesale price, $w_{CP}(k)$; the supplier's optimal wholesale price, w^*_S; and the supply chain coordinating wholesale price, w^*_{SC}. According to Zhang (2010), and Desinice (2012), the markdown ratio λ in the fashion industry is usually a constant, such as 0.5 (Zhang 2010). Here let $\lambda = 0.5$ and the following Figure 5.1 shows w_{CP}, w^*_{SC}, and w^*_S vs. *MPSR (k)*.

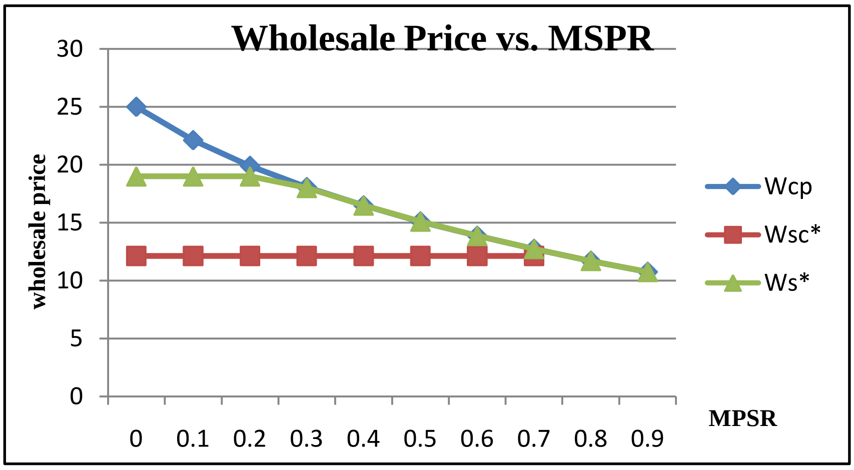

Figure 5.1, w_{CP}**,** w^*_{SC}**, and** w^*_S **vs. MPSR (k)**

Figure 5.1 reveals that when the MPSR is sufficiently small, w_{CP} is larger than w^*_S, which implies that the retailer will always accept the contract when the supplier offers the wholesale price that maximizes his expected profit. When the MPSR increases, both w_{CP} and w^*_S decrease until they converge to the same number.

With the current set of parameters, it can be shown that $\hat{k} = 0.758$. In other words, if the MPSR is too large, for example MPSR>0.75, coordination is not possible. The above observation is based on the analytical results. The next step is to study how the pricing decisions of human subjects change when the MPSR varies. It is also worthwhile to investigate how MPSR concern affects the subjects' performances with respect to their expected profits and profit uncertainties in both absolute terms (profit standard deviation) and relative terms (profit coefficient of variation (CV)).

5.3.Laboratory Setting

In our laboratory experiments, human subjects acted as suppliers who were responsible for deciding the wholesale price of the MMP. The role of the risk neutral retailer was played by a computer. The supplier subjects were uninformed about the existence of the retailer's MPSR concern. They were only told that the retailer would choose to accept or decline the offer: (i) if the retailer accepts the offer, she will automatically place an order according to certain decision criteria and logic; (ii) if the retailer declines the offer, she will order nothing. The retailer (computer) was assumed to be fully rational and would make its ordering decision in response to the offered wholesale price before the demand is realized[15]. A zero order quantity meant that the retailer rejected the contract.

The parameters in our experiments were set based on the observations made in our fashion industry survey. Specifically, the parameter settings were scaled based on company data obtained from Lady Forever, a Chinese apparel supplier. In the experiments, production cost (c =8), retail price (r =25), and markdown price ratio (λ =0.5) were based on Lady Forever data. The market demand was uniformly distributed between 0 and 300.

The event sequence in our laboratory experiments was as follows. First, the

[15] Since this research focuses on how the retailer's MPSR affects the performance of the supply chain and its agents, we adopt such an experimental arrangement for the sake of clarity. As a result, this paper is different from Cui et al. (2007) in the literature.

supplier offered an MMP ($w, b = w/2$). Next, the retailer decided whether to accept or reject the contract. The criterion of contract acceptance was as follows. If the ratio of her expected profit over that of the supply chain exceeded her MPSR, the retailer would accept the contract; otherwise, she would reject it. If she accepted the contract, she would order at the theoretically optimal quantity. After that, demand materialized and the corresponding resulting profits for both parties were calculated. If the contract was rejected, profits for both parties were zero. In our experiments, six MPSR-concern scenarios were considered: MPSR =0, 0.1, 0.3, 0.5, 0.75, or 0.9. Note that under the above mentioned setting, the supplier would theoretically achieve the maximum expected profit when MPSR=0.3, and the threshold wholesale price could coordinate the supply chain when MPSR=0.75.

On average, 16 subjects participated in each scenario. The subjects did not know which scenario they were playing. All of the subjects were both full-time fashion industrialists and part-time postgraduate students at The Hong Kong Polytechnic University[16]. All of the experimental sessions were conducted at the university computer labs and followed the same protocol.

At the beginning of the experiments, participants read the experiment instruction (see Appendix C3) that explained the rules of the game, the software used,

[16] We have 96 human subjects in total in our experiments which include 29 males and 67 females. Most of them are merchandisers and buyers in the TC industry. They are holding managerial/senior positions.

and the payment methods. A briefing presentation was made to ensure that subjects understood the flow of the experiment. Then a screening test was conducted to double-check that subjects fully understood our experiment settings, especially the implementation of the MMP.

During the game, subjects were asked to make repeated decisions, and in each scenario a subject needed to play 60 rounds. Decisions made between the rounds were considered independently. The subjects could see the history of each round, including his prior decisions (wholesale price and the corresponding markdown price); the market realized demand; the retailer's order quantity; the realized profits of the retailer, the supply chain, and himself; the percentage of his profit over that of the supply chain; and that of the retailer over the whole supply chain. Earning money was the subjects' only incentive. The show-up fee was 40 Hong Kong dollars (HKD) (about 5USD). The sessions lasted approximately 60 minutes, and the average earning was 100HKD (about 13USD).

In the following sections, the supplier and the retailer are referred as the *human supplier* and the *automated retailer* (played by the computer), respectively.

5.4.Experimental Results

In this section, the data derived from our laboratory experiments was analyzed and the behavior of the supplier when facing an MPSR-concerned retailer was investigated. The average wholesale price and the average profit of each supply chain party were calculated. A similar method was used by Schweitzer and Cachon (2000) and Kalkanci et al. (2011). In each scenario, each subject played 60 rounds.

First, the relationship between the MPSR and contract acceptance were examined. In addition, the relationship between the MPSR and two supply chain performance measures, the average wholesale price and profit were investigated.

Hypothesis 1 (Contract Acceptance). *The supplier is more likely to get his contract accepted when the corresponding retailer has a lower MPSR.*

Hypothesis 2 (Average Wholesale Price). *The wholesale price statistically depends on the retailer's MPSR concern; specifically, when the MPSR is higher (a) the average wholesale price and (b) the average accepted wholesale price are lower.*

Hypothesis 3 (Channel Members' Profit Performance). *The profit performance of the supply chain parties statistically depends on the retailer's MPSR concern.*

Here, a linear regression model was conducted to investigate the proposed relationships between the MPSR and supply chain performance measures. The results are summarized in Table 5.2.

Table 5.2. Relationship between the MPSR and supply chain performance measures

Supply chain performance measures	Linear Relationship to the MPSR
1: Contract acceptance	— **
2a: Accepted average w in the second 30 rounds	— **
2b: Average w in all 60 rounds	— **
3a: Supplier's average profit in all 60 rounds	— **
3b: Supplier's profit Std in all 60 rounds	— **
3c: Supplier's profit CV in all 60 rounds	—
3d: Retailer's average profit in all 60 rounds	+ **
3e: Retailer's profit Std in all 60 rounds	+ **
3f: Retailer's profit CV in all 60 rounds	—
3g: Supply chain's average profit in all 60 rounds	—
3h: Supply chain's profit Std in all 60 rounds	+ **
3i: Supply chain's profit CV in all 60 rounds	+ **

Notes. For Hypotheses 1-3. $**p < 0.01$.

Std=standard deviation; CV= coefficient of variation.

As expected, the MPSR has a significant effect on contract acceptance (Beta = -0.619, $p < 0.01$ for Hypothesis 1). A higher MPSR makes the retailer more likely to reject the contract. When the MPSR increases, the supplier needs to lower his wholesale price (Beta= -0.847 and $p < 0.01$ for Hypothesis 2a; Beta= -0.766 and $p <$ 0.01 for Hypothesis 2b). This confirms the numerical experimental result that a high MPSR reduces the value of the MPSR-dependent threshold wholesale price below which the retailer accepts the contract.

Figures 5.2 and 5.3 illustrate the relationship between the average wholesale price and the MPSR. Supplementary details regarding the wholesale price under different MPSRs are given in Table A of Appendix C2. Figures 5.2 and 5.3, based on the theoretical results discussed in Section 5.2, depict the MPSR-dependent threshold wholesale price, the optimal wholesale price that the supplier should offer, and the wholesale price that coordinates the supply chain. It is found that when the MPSR is large, the threshold wholesale price w_{CP} overlaps with the supplier's optimal wholesale price w_S^*. However, they are clearly separated from each other when the MPSR is small (MPSP=0, 0.1 or 0.3). It also shows that w, the wholesale price offered by the human supplier, is closer to the supplier's optimal wholesale price w_S^* than to the threshold wholesale price w_{CP}. Moreover, the supplier lowers his wholesale price when the retailer holds a higher MPSR.

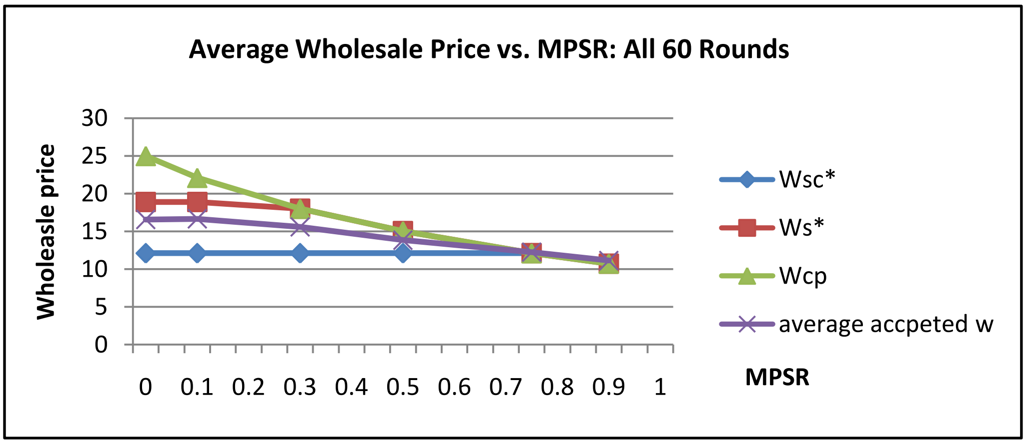

Figure 5.2 Average wholesale price vs. MPSR: all 60 rounds

Hypothesis 3 investigates the statistical relationship between the supply chain parties' profit performance and the retailer's MPSR concern. Specifically, it is interesting to see how the retailer's MPSR concern affects both the average profit and profit uncertainty of each party (See Lau and Lau (1999), Cachon (2003), Tomlin (2006), Choi et al. (2008), Shen et al. (2013) and the references therein for a discussion of expected profit and profit uncertainty in a supply chain).

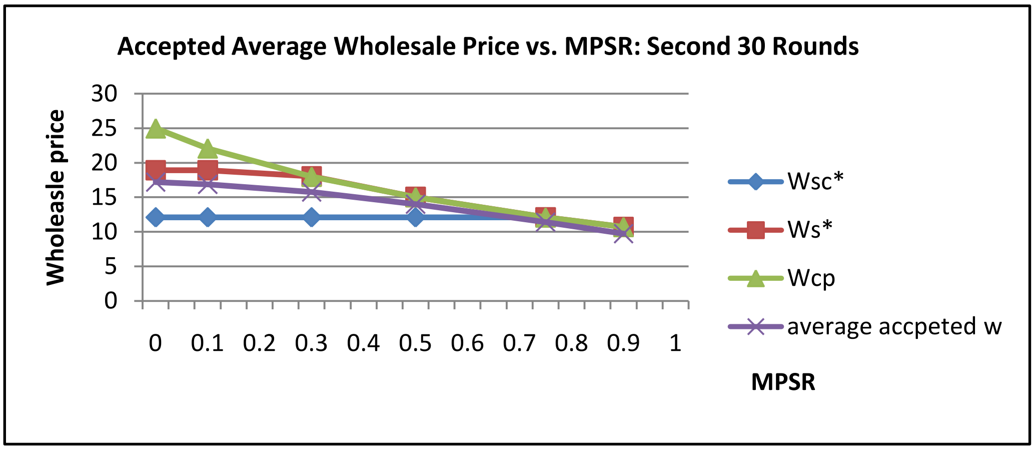

Figure 5.3 Accepted average wholesale price vs. MPSR: second 30 rounds.

In Hypothesis 3, the profit performance measures including the average profit, its standard deviation, and the corresponding CV are calculated. The details are listed in Table B of Appendix C2. Hypothesis 3 is supported, as the MPSR concern has a direct effect on the average profit of the supplier and the retailer (Beta=-0.852, $p <$ 0.01 for Hypothesis 3a; Beta=0.640, $p < 0.01$ for Hypothesis 3d). The supplier's average profit reduces and that of the retailer increases when the retailer's MPSR increases. In addition, if the MPSR increases: then (i) the supplier's profit standard deviation decreases, and (ii) the retailer's profit standard deviation increases (Beta=-0.401, $p < 0.01$ for Hypothesis 3b; Beta=0.748, $p < 0.01$ for Hypothesis 3e). This implies that the presence of the retailer's MPSR concern actually helps reduce the supplier's profit uncertainty (standard deviation). For the supply chain, its profit standard deviation is positively correlated with the retailer's MPSR (Beta=0.728, $p < 0.01$ for Hypothesis 3h). However, the supply chain profit has no significant linear relationship with the retailer's MPSR (Beta=-0.216, $p > 0.01$ for Hypothesis 3g). This finding is counterintuitive and will be further explored in Section 5.4.

As the profits of the supplier and the retailer have different magnitudes, the profit CV, as a relative measure, can better quantify the associated profit uncertainty. It is found that the retailer's and the supplier's profit CVs have no statistically significant relationship with the retailer's MPSR concern (Beta=-0.229, $p = 0.027 > 0.01$ for Hypothesis 3f; Beta=0.089, $p = 0.397 > 0.01$ for Hypothesis 3c). However, the profit CV for the supply chain is positively correlated to the retailer's MPSR (Beta=0.614, $p < 0.01$ for Hypothesis 3i). For the whole supply chain, it is found find that both the profit standard deviation and CV increase when the retailer has a higher MPSR concern. This finding implies that when the retailer has a higher MPSR, the supply chain has a higher risk (profit uncertainty) in both absolute and relative terms. Thus, the presence of an MPSR concern leads to a higher supply chain risk. For the retailer, the relationship between her profit CV and the retailer's MPSR is not significant at the 0.01 level of significance, but if the significance level is adjusted from 0.01 to 0.05, it can claim that the retailer's profit CV is significantly associated with her MPSR. Therefore, the retailer's profit and the corresponding standard deviation both increase when her profit CV decreases when she holds a higher MPSR. The potential reason is that her profit increases at a faster rate than the corresponding standard deviation. This finding may provide a benchmark for the retailers' MPSR. Specifically, if the retailer cares more about her relative profit uncertainty, she will prefer a higher MPSR, whereas if she cares more about her absolute profit uncertainty, she will lower her MPSR.

Next, the supplier's learning effect is investigated. Among the 60 rounds played by each subject, subjects are assumed to be inexperienced in the first 30 rounds and experienced in the second 30 rounds. Hypothesis 4 is concerned with this learning effect.

Hypothesis 4 (Learning Effect). *The supplier's pricing decision is affected by his experience such that a) the average wholesale price is larger in the second 30 rounds, b) the accepted average wholesale price is larger in the second 30 rounds, and c) the* *contract acceptance rate is higher in the second 30 rounds.*

The results from the first 30 rounds is compared with those from the second 30 rounds and the descriptive statistics for wholesale prices in all of the treatments are illustrated in Table 5.3. In the statistical analysis, two paired comparisons are considered. In one it calculates the average wholesale price using all of the cases, regardless of whether the retailer accepts or rejects the contract, and in the other it calculates the accepted average wholesale price using only those cases in which the retailer accepts the contract.

Table 5.3. Paired comparisons between the statistics derived from the first 30 rounds and the second 30 rounds

	Inexperienced	Experienced
(i) Average w	14.20 (2.687)	14.48 (3.183)
(ii) Accepted average w	13.56 (2.999)**	14.48 (3.183)**
(iii) Number of contracts accepted	26.14 (5.036)**	28.06 (4.599)**

Notes. For Hypothesis 4. Standard deviations are reported in parentheses.
w =wholesale price. $**p < 0.01$.

The results of the statistical comparison, as shown in Table 5.3, are based on a one-sample Wilcoxon test (Siegel 1956, pp. 75-83). The results in Table 5.3 partially support Hypothesis 4. The hypothesis that the average wholesale price for the first 30 (inexperienced) rounds is statistically significantly different from that for the second

30 (experienced) rounds cannot be supported. This is unexpected as, theoretically, the contract is more likely to be rejected in the first 30 rounds than in the second 30 rounds, as it takes time for the supplier to learn about the retailer's MPSR. In another test comparing the rejected cases from the first 30 rounds with those from the second 30 rounds, the rejected average wholesale price offered by the inexperienced supplier is higher than the one offered by the experienced supplier (16.2 for the inexperienced and 15.8 for the experienced), whereas the accepted average wholesale price offered by the inexperienced supplier is lower than the one offered by the experienced supplier (13.56 for the inexperienced and 14.48 for the experienced). These two effects interact with each other and as a result, it has no overall significant difference between the average wholesale price for the experienced supplier and the price for the inexperienced buyer. The results shown in Table 5.3 help to conclude that the accepted average wholesale price is higher when the supplier is more experienced, as the experienced supplier has a better knowledge of the minimum wholesale price that his MPSR-concerned retailer will accept (which is the MPSR-dependent threshold wholesale price, w_{CP}). This knowledge enables him to offer a wholesale price that is acceptable to the retailer. Therefore, as a result of learning, when the supplier is more experienced the contract proposed by him is less likely to be rejected by the retailer.

5.4. Discussion: Profit Performance of the Supply Chain vs. MPSR

In this section, the relationship between the retailer's MPSR concern and the profit performance of the supply chain parties is further explored. The average profits of the supplier, the retailer, and the supply chain under different MPSRs[17] are depicted in Figure 5.4, which includes the data from all 60 rounds (for detailed data please refer to Table B in Appendix C2). As the benchmark case, the theoretical expected profit of the centralized supply chain is also depicted in Figure 5.4. The following behavioral observations are obtained.

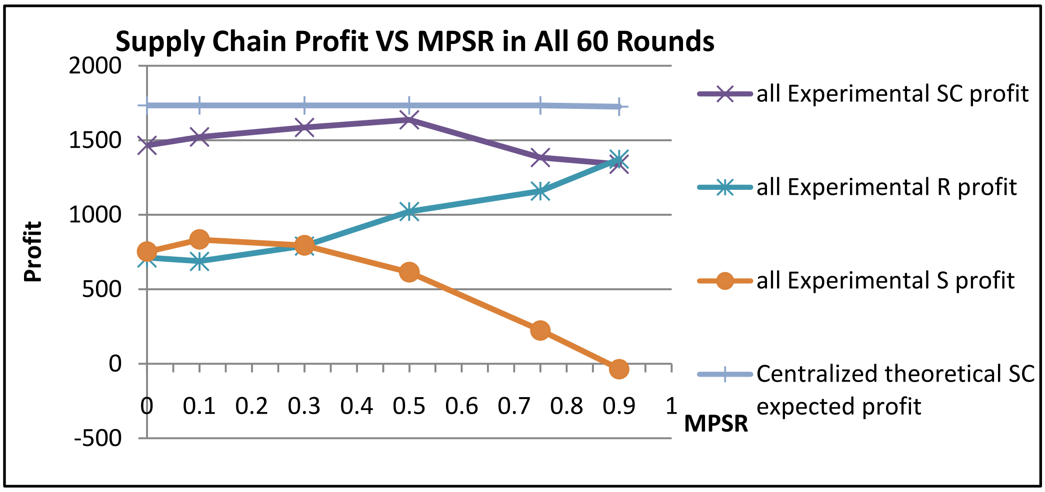

Figure 5.4 Supply chain profit vs. MPSR: All 60 Rounds.

Behavioral Observation 1: The profits of the supplier and the retailer are approximately equal when the MPSR=0.

[17]In Hypothesis 3, the supply chain performance with both inexperienced and experienced scenarios is studied.

This observation implies that under an MMP, when the retailer has no MPSR concern, the supplier tends to split the profit approximately equally between the retailer and himself. This phenomenon is also observed by Keser and Paleologo (2004) and by Haruvy et al. (2012) in their consideration of a wholesale price contract. In contrast to the wholesale price contract scenario, in which the supplier faces no inventory risk in a make-to-order system, in our experiments, the human suppliers understand that under an MMP they partially bear the overstocking inventory risk. Facing a retailer with no MPSR concern, human suppliers tend to offer the wholesale price that leads to more or less equitable outcomes. This is aligned with the theories of inequity aversion and fairness discussed in Fehr and Schmidt (1999) and Bolton and Ockenfels (2000).

Behavioral Observation 2: Compared to no MPSR concern (MPSR=0), a moderate MPSR concern (MPSR=0.3) might improve the profit performance of both the supplier and the retailer.

When the MPSR is moderate (MPSR=0.3), both the supplier and the retailer obtain higher profits than those when the retailer has no MPSR concern (MPSR=0). Recall that the retailer's profit increases with her MPSR concern (Hypothesis 3d in Table 5.2), and that MPSR=0.3 is the ratio under which the supplier theoretically achieves the maximum expected profit. It is therefore unsurprising to note the above reported laboratory experiments confirm that the MPSR=0.3 condition leads to a win-win outcome for the supplier and the retailer. This also implies that the whole supply chain obtains a higher profit under the MPSR=0.3 condition than that under the MPSR=0 condition. Thus a moderate MPSR may be beneficial not only to the retailer, but also to the supplier and the supply chain. In addition, when the MPSR=0.3, the supplier tends to split the profit equally with the retailer. This is different from the theoretical results, which suggest that such a situation would happen when MPSR=0.5. A possible reason is that a supplier with an MPSR concern is aware of the retailer’s possible rejection and therefore tends to offer a more generous (i.e., lower) wholesale price than he should. This is confirmed by the support for our Hypotheses 1 and 2. In fact, the supplier’s (retailer’s) profit is less (more) than its theoretical values (see Figure 5.5). These two opposite effects on the profits of the two channel members might result in an approximately equal split of profit at an MPSR smaller than 0.5.

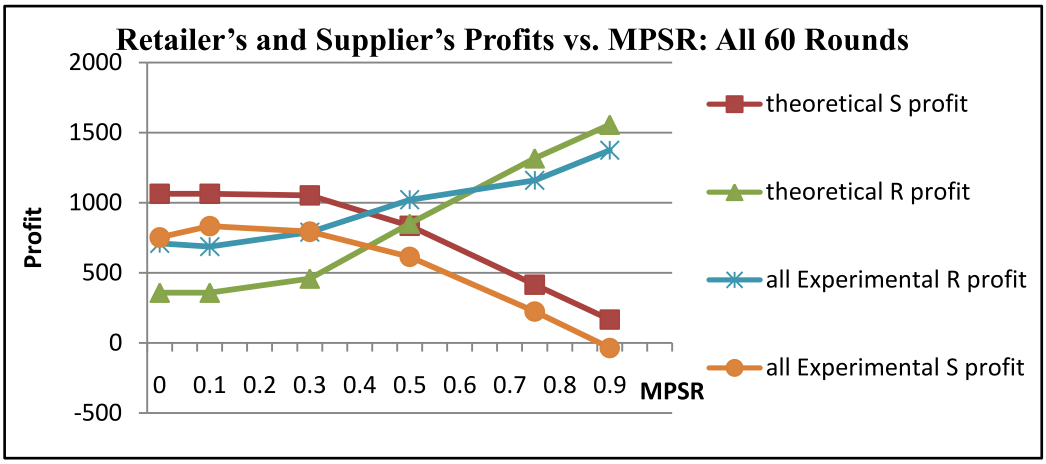

Figure 5.5 Retailer's and supplier's profits vs. MPSR: all 60 rounds.

Behavioral Observation 3: The supply chain achieves the best outcome when the MPSR=0.5, that is, when neither party faces disadvantageous inequality.

It is interesting to find that the whole supply chain achieves the best performance, with its profit close to the theoretically optimal one, when the MPSR=0.5, as shown in Figure 5.4. An MPSR=0.5 implies that the retailer seeks to get 50% of the supply chain profit; in other words, she tends to split the profit equally with her supplier. In this case, neither party faces disadvantageous inequality. In this sense, the retailer is "fully" fair.

Reputation plays an essential role in the natural history of economic life and is an effective means of enforcing cooperation (Milgrom et al. 1990). The evolution of reputation is linked to the evolution of fairness; fairness evolves if the proposer can obtain some information on what deals the responder accepted in the past (Nowak et al., 2000). In a supply chain, each trading party has his or her own fairness concern. In our laboratory experiments, the human supplier makes his pricing decision based on not only his own fairness concern, but also on the observed retailer's self-serving fairness concern. As a contract proposer, he obtains information on what deals the retailer accepted in the past and on what percentage of the supply chain profit he occupied. With this information, he is able to determine the retailer's self-serving fairness concern, through which the retailer's reputation is gradually built. When the MPSR=0.5, the retailer is fully fair. As a result, a good reputation emerges, which further creates a sense of cooperation between the retailer and the supplier. Consequently, the supplier tends to offer a contract that maximizes the total pie—the supply chain profit. So an appropriate MPSR (e.g., 0.5) expresses the message of fairness and helps to build and maintain a reputation for cooperation between the trading partner. The literature on supply chain management shows that building cooperation over time increases the efficiency and effectiveness of the relationship and improves the business outcome (Choi and Hartley 1996, Carr and Pearson 1999, Primo and Amundson 2002, Li et al. 2008). Consequently, the whole supply chain achieves the best performance in the long run.

The statistical analysis given in Section 5 shows that the retailer's MPSR has no significant linear effect on the whole supply chain profit. The potential reason for this result may be that the supply chain achieves the highest profit when the retailer's MPSR=0.5. The line plotted in Figure 5.4 suggests that there may be a nonlinear, inverse U-shape relationship between the supply chain profit and the retailer's MPSR. Accordingly, a quadratic regression analysis is conducted to redefine the effect of the retailer's MPSR on the supply chain profit. The modified regression analysis confirms that the supply chain profit and the retailer's MPSR do exhibit a quadratic relationship, i.e., an inverse U-shape curve ($\beta_1 = 736.8$, $\beta_2 = -1016.9$, $p < 0.01$).

Behavioral Observation 4: Retailer's rejection leads to the failure of supply chain coordination under the coordinating MPSR, that is, when MPSR=0.75.

The average profits of the supplier, the retailer, and the supply chain under different MPSRs are depicted in Figure 5.6 (which excludes those rounds in which contracts are rejected by the retailer). Based on the experimental data shown in Figure 5.6, it is found that when excluding those cases in which the MMP is rejected by the retailer, the supply chain achieves a centralized performance under MPSR=0.75 (see Figure 5.6). However, when both contract rejection and acceptance cases are included, the supply chain fails to achieve a centralized performance when MPSR=0.75 (see Figure 5.4). Recall that under MPSR=0.75 the MPSR-dependent threshold wholesale price and the corresponding MMP theoretically coordinate the supply chain. A comparison between Figures 5.4 and 5.6 suggests that the retailer's rejection leads to the failure of supply chain coordination. A previous study by Haruvy et al. (2012) also shows that the retailer's rejection is the primary reason that coordinating contracts fail to coordinate. Based on our laboratory results, the following two points are shown. First, the retailer's rejection is the reason that the coordinating MMP under our setting fails to coordinate the supply chain. Second, based on the learning effect (Hypothesis 4), assume that the supplier can extract the information that the retailer's MPSR is 0.75 through learning. Once the supplier has this knowledge, he will offer a wholesale price as high as the MPSR-dependent threshold wholesale price associated with MPSR=0.75. This will allow him to maximize his own profit, while still offering a contract that is acceptable to the retailer. Consequently, the supply chain profit should be approximately equal to the theoretically optimal one. Thus, the supply chain becomes coordinated.

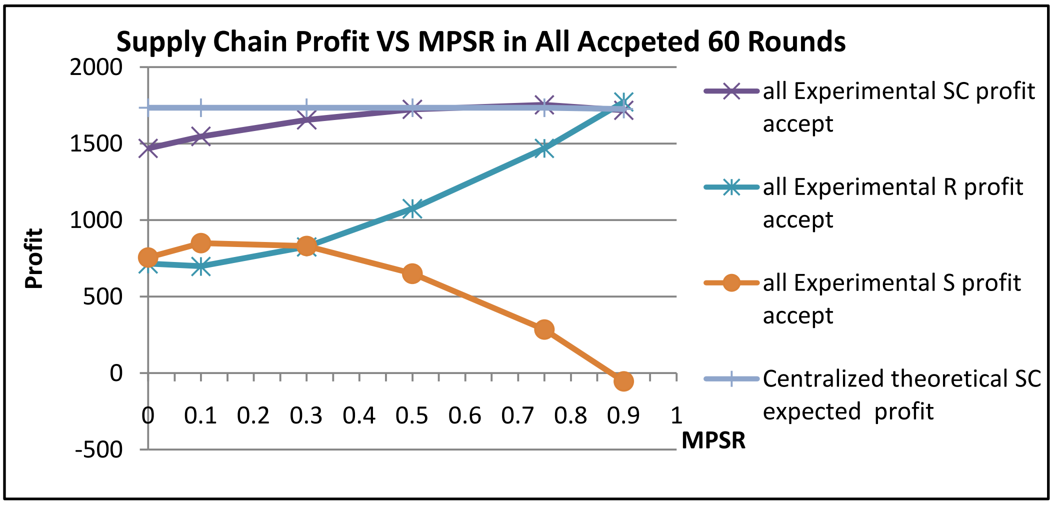

Figure 5.6 Supply chain profit vs. MPSR: all accepted rounds.

Behavioral Observation 5: Suppliers are likely to go bankrupt when facing a retailer with a high MPSR.

From Figures 5.4 and 5.6, under MPSR=0.9, the human supplier obtains a negative profit. This observation implies that the suppliers are more likely to go bankrupt when the retailer has a high MPSR concern, as the supplier has a very thin profit margin when working with a retailer with a strong self-serving fairness concern. Under an MMP, the supplier also partially shares the inventory risk of overstocking by paying the retailer a markdown price over each unit of leftovers. These two forces may result in supplier's bankruptcy.

5.5. Summary and Managerial Implications

In this chapter, a two-echelon supply chain in the context of an MMP with an MPSR-concerned retailer was investigated by laboratory experiments. The key question of how a retailer's self-serving fairness concern, i.e., her MPSR concern, affected supply chain performance was examined.

The experiments produced several interesting findings. First, a retailer was more likely to reject a contract when she held a higher MPSR, which led to the failure of supply chain coordination. Second, the average wholesale price offered by the supplier decreased as the MPSR increased. Moreover, the experimental wholesale price was closer to the theoretically optimal wholesale price for the supplier than to the MPSR-dependent threshold wholesale price. Third, the effects of the MPSR concern on the performance of supply chain parties with respect to their profits, corresponding standard deviations, and CVs were revealed. In particular, a higher (lower) MPSR was preferred by a retailer who cared more about her relative (absolute) profit uncertainty. For the whole supply chain, the presence of an MPSR concern led to higher profit uncertainty in both absolute and relative terms. All of these findings had important managerial implications for the real world design of supply chain contracts, such as MMP, when an MPSR concern was present.

The observation implied that human suppliers tended to offer wholesale prices that led to more or less equitable outcomes when facing a retailer with no MPSR concern (MPSR=0). A moderate MPSR concern (MPSR=0.3) might create a better win-win outcome for both the supplier and the retailer than a retailer without an MPSR concern (MPSR=0). Moreover, when the MPSR=0.5, that is, when neither party faced disadvantageous inequality, the whole supply chain achieved the best performance and the supply chain profit would most closely match the theoretically optimal one. Our results implied that a retailer's reputation for fairness created a sense of cooperation between the supplier and herself. This was an important finding, as it provided strong evidence that treating supply chain partners fairly would result in the best supply chain performance. In addition, our observation implied that retailer's rejection was the primary reason why coordinating MPSRs (MPSR=0.75) and the corresponding coordinating MMPs failed to coordinate the supply chain. Lastly, our observation implied that when the retailer had a strong self-serving fairness concern (MPSR=0.9), the suppliers would be more likely to go bankrupt. For all of these reasons, those laboratory experiment based results concluded that it is crucial to incorporate the retailer's self-serving fairness concern into the design of the supply chain contract.

Notice that the study in this chapter was subject to two main limitations that pointed toward fruitful directions for future research. First, in our experiments, the behavior of the supplier was studied only and the role of the retailer was played by the computer. This design was intentional as such an experimental setting guaranteed that the retailer was fully rational, risk neutral, and had the appropriate MPSR concern. This allowed us to focus on the supplier's pricing decision. Second, it was assumed that a fixed MPSR parameter was present for each scenario. In reality, the retailer's MPSR might change along with changes in the environment, such as the business and economic situation. Relaxing these assumptions and remodeling the experiments would open doors to future research extensions.

6. Conclusion

This thesis focused on examining the MMP in the TC industry. First, case studies focusing on an American TC company and a Chinese one were conducted in Chapter 3 to explore their real industrial practices of MMP adoption. It was found that the cultural factors such as power distance and collectivism/individualism would affect contract selection, contract management, supplier-retailer leadership and supplier-retailer relationship in supply chain. More specifically, in a relatively high degree of power distance and collectivism country, the Chinese TC company was more willing to play the role of the leader to manage its supply chain and also offer the markdown money to his retailers voluntarily. However, due to deteriorating economic circumstance, the Chinese firm was recently more risk-averse than before and the provision of markdown money was more optional. On the other hand, in a relatively low degree of power distance and individualism country, the American TC company was more likely to emphasize on its own interest in trading; as a result, the self-serving fairness concern was raised. The American TC company had to bargain with its retailers and was asked to provide the markdown money involuntarily.

Based on the findings in the case studies reported in Chapter 3, an analytical model with a risk averse supplier in a two-echelon TC supply chain was investigated in Chapter 4. To be specific, in Chapter 4, under the proposed coordinating MMP: (i) the optimal markdown price was found to be influenced by the supplier's and the entire supply chain's risk tolerance levels; (ii) the supplier's and the entire supply chain's "profit-coefficients of variation" were affected by the supply chain's risk tolerance level. Moreover, the numerical analyses with real company data demonstrated that if both of the two sampled fashion companies applied the proposed coordinating MMP, they would have gained a much better performance with the consideration of risk-profit tradeoff under the MV framework, and the corresponding fashion supply chain would be more efficient.

After that, in Chapter 5, the effect of TC buyer's self-serving fairness concern was investigated experimentally. The experiments yielded several interesting findings. First, it was found that a retailer would be more likely to reject a contract when she held a higher MPSR, and this led to the failure of supply chain coordination. Second, a higher MPSR would induce a lower average wholesale price. Third, there was an inverse U-shaped relationship between supply-chain profit and the retailer's MPSR; in other words, the average profit of the supply chain would first increase and then decrease as the retailer's MPSR increased. Moreover, the presence of an MPSR concern would lead to higher supply chain profit uncertainty, both in absolute (standard deviation) and relative (coefficient variation) terms. It was further observed that when the retailer had no MPSR concern, the supplier would tend to split the supply chain profit equally with the retailer, whereas when the retailer's MPSR equaled 0.5 (i.e., when the retailer wanted to split the supply chain profit equally with the supplier), the whole supply chain would achieve the best performance with the supply chain profit mostly stayed close to the theoretically optimal one.

The above findings and managerial insights concluded this thesis research.

7. Future Research Directions

Future research could be conducted in three-fold, namely in an empirical, analytical and experimental way.

First, empirically, future research can be conducted by expanding the scope. For example, issues such as uncertainty avoidance, short-term/long-term oriented culture (Zhao et al., 2008), kinds of incentive alignment supply chain contracts, can all be examined. In addition, exploring by case studies the use of supply chain contracts in more countries (Su et al. 2009; Kim 2012), e.g., those in Europe, can provide further evidence and insights on the existing problems.

Second, analytically, it is promising to explore the issues on reverse logistics in a TC supply chain with product returns and probable recycling of materials. The works done in (Chen et al. 2004; Li et al. 2012; Li et al. 2012; Eunsuk and Beverley 2013) provide great references for this extension. Moreover, it is interesting to consider the supply chain coordination problem in which the retailer can control both the quantity and pricing decisions (Chiu et al. 2009; Choi et al. 2010; Chen et al. 2010; Dong and Leung 2010; Chiu et al. 2011c; Liu et al. 2012).

Third, experimentally, it is interesting to extend the study to examine the scenario when both the buyer and the supplier are played by the human subjects. It will then become feasible to investigate how both agents will behave with respect to self-serving fairness and their respective performance in the supply chain (Katok and Wu 2008; Davis and Katok 2012; Wu 2013).

Appendix A: Interview Questions for Chapter 3

1. Could you please introduce your company?
2. What kind of supply chain contracts are you adopting with your retail buyers and how?
3. How would you evaluate the adopted supply chain contracts with your retailers?
4. Have the adopted supply chain contracts helped to build up the good relationship with your retail buyers and how?
5. Do you expect these adopted supply chain contracts be used in a longer- or shorter-term?
6. How would you describe the relationship between you and your retail buyers?
7. Who is responsible for managing this relationship and how?

Appendix B – Mathematical Proofs for Chapter 4

B.1. Proof of Theorem 4.1

First, for (a), the optimal supply chain quantity is $q_{R,EP^*} = q_{SC,EP^*}$ .Thus from (4.3) and (4.4), it can be obtained that:

$$q_{SC,EP^*} = q_{R,EP^*} \Rightarrow (r-c)/(r-v) = (r-w_{EP}^*)/(r-b_{EP}^*)$$

$$w_{EP}^* = r - \frac{(r-c)(r-b_{EP}^*)}{r-v} \tag{4.5}$$

Substituting (4.5) into $EP_S(q_{SC,EP^*})$ yields:

$$EP_S(q_{SC,EP^*}) = (w_{EP}^* - c)q_{SC,EP^*} - (b_{EP}^* - v)n(q_{SC,EP^*}) = \frac{b_{EP}^*(r-c) + r(c-v) - c(r-v)}{r-v} q_{SC,EP^*}$$

$$-(b_{EP}^* - v)n(q_{SC,EP^*})$$

$$\frac{\partial EP_S(q_{SC,EP^*})}{\partial b_{EP}^*} = \frac{r-c}{r-v} q_{(SC,EP^*,b_{EP}^*)} - n(q_{(SC,EP^*,b_{EP}^*)}) = \frac{r-c}{r-v} q_{(SC,EP^*,b_{EP}^*)} - \int_0^{q_{(SC,EP^*,b_{EP}^*)}} F(x)dx$$

$$= \frac{r-c}{r-v} q_{(SC,EP^*,b_{EP}^*)} - F(q_{(SC,EP^*,b_{EP}^*)})q_{(SC,EP^*,b_{EP}^*)} + \int_0^{q_{(SC,EP^*,b_{EP}^*)}} xf(x)dx > 0$$

(4.6)

The result that $dEP_S(q_{SC,EP^*})/db_{EP}^* > 0$ indicates $EP_S(q_{SC,EP^*})$ is increasing in b_{EP}^*.

From Table 4.3 and the optimization problem P1, it can be obtained that:

$$SP_S(q_{SC,EP^*}) = (b_{EP}^* - v)\sqrt{\xi(q_{SC,EP^*})} \le k_S$$

$$\Rightarrow b_{EP}^* \le \frac{k_S}{\sqrt{\xi(q_{SC,EP^*})}} + v$$

AS $EP_S(q_{SC,EP^*})$ is increasing in b_{EP}^*, and $b_{EP}^* \le \frac{k_S}{\sqrt{\xi(q_{SC,EP^*})}} + v$ is required, the optimal markdown price b_{EP}^* for the channel coordination is:

$$b_{EP}^{*} = \frac{k_S}{\sqrt{\xi(q_{SC,EP^*})}} + v. \tag{4.7}$$

Substituting b_{EP}^{*} into (4.5), the optimal wholesale price w_{EP}^{*} can be obtained:

$$w_{EP}^{*} = \frac{(\frac{k_S}{\sqrt{\xi(q_{SC,EP^*})}} + v)(r-c) + r(c-v)}{(r-v)}. \tag{4.8}$$

Next, for (b): To achieve mean-variance supply chain coordination, it requires $q_{R,EP^*} = q_{SC,MV^*}$. Thus

$$q_{R,EP^*} = q_{SC,MV^*} \Rightarrow q_{SC,MV^*} = F^{-1}(\frac{r-w_{MV}^{*}}{r-b_{MV}^{*}}). \tag{4.9}$$

Then it can be obtained that: $b_{MV}^{*} = r - \frac{r-w_{MV}^{*}}{F(q_{SC,MV^*})}$. (4.10)

The optimal wholesale price w_{MV}^{*} is:

$$w_{MV}^{*} = r-(r-b_{MV}^{*})F(q_{SC,MV^*}). \tag{4.11}$$

Substituting (4.11) into $EP_S(q_{SC,MV^*})$ yields:

$$EP_S(q_{SC,MV^*}) = (w_{MV}^{*}-c)q_{SC,MV^*} - (b_{MV}^{*}-v)n(q_{SC,MV^*})$$

$$= [(r-c)-(r-b_{MV}^{*})F(q_{SC,MV^*})]q_{SC,MV^*} - (b_{MV}^{*}-v)n(q_{SC^*})$$

Thus, $\frac{\partial EP_S(q_{SC,MV^*})}{\partial b_{MV}^{*}} = q_{SC,MV^*}F(q_{SC,MV^*}) - n(q_{SC,MV^*})$

$$= q_{(SC,MV^*,b_{MV}^{*})}F(q_{(SC,MV^*,b_{MV}^{*})}) - \int_0^{q_{(SC,MV^*,b_{MV}^{*})}} F(x)dx$$

$$= q_{(SC,MV^*,b_{MV}^{*})}F(q_{(SC,MV^*,b_{MV}^{*})}) - q_{(SC,MV^*,b_{MV}^{*})}F(q_{(SC,MV^*,b_{MV}^{*})})$$

$$+ \int_0^{q_{(SC,MV^*,b_{MV}^{*})}} xf(x)dx > 0$$

So $dEP_S(q_{SC,MV^*})/db_{MV}^{*} > 0$, (4.12) which indicates that $EP_S(q_{SC,MV^*})$ is increasing in b^*_{MV} ,

From Table 4.3 and the optimization problem P1, it can be obtained that:

$$SP_S(q_{SC,MV^*}) = (b^*_{MV} - v)\sqrt{\xi(q_{SC,MV^*})} \le k_s$$

$$=> b^*_{MV} \le \frac{k_s}{\sqrt{\xi(q_{SC,MV^*})}} + v$$

Because $EP_S(q_{SC,MV^*})$ is increasing in b^*_{MV} and $b^*_{MV} \le \frac{k_s}{\sqrt{\xi(q_{SC,MV^*})}} + v$ is required, the optimal markdown price b^*_{MV} for channel coordination is:

$$b^*_{MV} = \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} + v \tag{4.13}$$

Then the optimal wholesale price w^*_{MV} can be found to be:

$$w^*_{MV} = r - (r - v - \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}})F(q_{SC,MV^*}) \tag{4.14}$$

B.2. Proof of Corollary 4.1.

Based on (4.5) that $w^*_{EP} = r - \frac{(r-c)(r-b^*_{EP})}{r-v}$, so w^*_{EP} is increasing in b^*_{EP} . According to (4.11) that $w^*_{MV} = r - (r - b^*_{MV})F(q_{SC,MV^*})$, w^*_{MV} is increasing in b^*_{MV} . Thus the optimal wholesale price w^*_l is increasing in the optimal markdown price b^*_l .

B.3. Proof of Lemma 4.1. For (a), if k_{SC} is a fixed parameter, the optimal order quantity (q_{SC,l^*}) is a constant. Hence, according to (4.13), $b^*_{MV} = \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} + v$ is obtained, which implies that b^*_{MV} is increasing in k_S , and as a result, w^*_{MV} is increasing in k_S. For (b), according to (4.12), $dEP_S(q_{SC,MV^*})/db^*_{MV} > 0$ is obtained, which implies that EP_S is increasing in b^*_{MV}. When k_{SC} is a constant, b^*_{MV} is increasing in k_S, and so EP_S is increasing in k_S. The fixed optimal order quantity (q_{SC,l^*}) implies that EP_{SC} is a constant and $EP_{SC} = EP_S + EP_R$. Thus, when EP_S is increasing in k_S, EP_R is decreasing in k_S.

B.4. Proof of Lemma 4.2.

According to (4.13) and (4.14), it can be obtained that

$$w_{MV} - b_{MV} = r - \left((r - v) - \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} \right) F(q_{SC,MV^*}) - \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} - v$$

$$= \left(1 - F(q_{SC,MV^*})\right) \left(r - v - \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} \right)$$

Notice that $\left(1 - F(q_{SC,MV^*})\right) > 0$, and when k_{SC} is a constant, the optimal quantity q_{SC,MV^*} is a constant, too. Hence, the difference between the optimal wholesale price and markdown price is decreasing in k_S.

B.5. Proof of Proposition 4.1.

According to (4.12) that $dEP_S(q_{SC,MV^*})/db^*_{MV} > 0$, a higher value of b^*_{MV} leads to a higher value of $EP_S[q_{SC}(b^*_{MV})]$, therefore, $EP_S[q_{SC}(b^*_{MV})]$ is increasing in b^*_{MV}.

B.6. Proof of Proposition 4.2.

For (a), since $\xi(q)$ is increasing in q, and according to P(SC), $\xi(q_{SC,MV^*}) \le \left(\frac{k_{SC}}{r-v}\right)^2$ is obtained. When k_{SC} increases, q_{SC,MV^*} can either increase or remain the same (non-decreasing) if $k_{SC} \le SP_{SC}(q_{SC,EP*})$, and $q_{SC,MV^*} = q_{SC,EP^*}$ $\forall k_{SC} > SP_{SC}(q_{SC,EP*})$. When k_S is fixed, equation (4.13) implies that a larger q_{SC,MV^*} would lead to a smaller b^*_{MV}. Hence, if $k_{SC} \le SP_{SC}(q_{SC,EP*})$, the optimal markdown b^*_{MV} is non-increasing in k_{SC}. For (b), substituting (4.13) that $b^*_{MV} = \frac{k_S}{\sqrt{\xi(q_{SC,MV^*})}} + v$ into $SP_R(\mathrm{q}_{\mathrm{SC,MV^*}}) = (r - b^*_{MV})\sqrt{\xi(q_{SC,MV^*})}$, $SP_R(q_{SC,MV^*}) = (r-v)\sqrt{\xi(q_{SC,MV^*})} - k_S$ is obtained. As q_{SC,MV^*} is non-decreasing in k_{SC}, when k_S is a constant, $SP_R(q_{SC,MV^*})$ is non-decreasing in k_{SC}.

B.7. Proof of Proposition 4.3.

Substituting (4.14) into $\frac{SP_R(q_{SC,MV^*})}{EP_R(q_{SC,MV^*})}$ yields:

$$\frac{SP_R(q_{SC,MV^*})}{EP_R(q_{SC,MV^*})} = \frac{(r-b^*_{MV})\sqrt{\xi(q_{SC,MV^*})}}{(r-w^*_{MV})q_{SC,MV^*} - (r-b^*_{MV})n(q_{SC,MV^*})}.$$

$$= \frac{(r-b^*_{MV})\sqrt{\xi(q_{SC,MV^*})}}{(r-b^*_{MV})F(q_{SC,MV^*})q_{SC,MV^*} - (r-b^*_{MV})n(q_{SC,MV^*})}$$

$$= \frac{\sqrt{\xi(q_{SC,MV^*})}}{F(q_{SC,MV^*})q_{SC,MV^*} - n(q_{SC,MV^*})}.$$

When k_{SC} is fixed, q_{SC,MV^*} is a constant. Hence, $\dfrac{SP_R(q_{SC,MV^*})}{EP_R(q_{SC,MV^*})}$ is a constant, which is independent of b^*_{MV}. In other words, $\dfrac{SP_R(q_{SC,MV^*})}{EP_R(q_{SC,MV^*})}$ is independent of k_S .When k_{SC} varies, $\dfrac{SP_R(q_{SC,MV^*})}{EP_R(q_{SC,MV^*})}$ will change. Therefore, $\dfrac{SP_R(q_{SC,MV^*})}{EP_R(q_{SC,MV^*})}$ is independent of k_s, but dependent of k_{SC}.

Appendix C – For Chapter 5

Appendix C1 - All Mathematical Proofs.

C1.1. Proof of Theorem 5.1 For (a) and (b).

Given an MMP $\{w, \lambda w\}$, the retailer's expected profit when ordering q units is

$$E\pi_R(q) = (r-w)q - (r-\lambda w)q^2/2B.$$

It can be easily shown that $E\pi_R(q)$ is strictly concave in q, and that the optimal order quantity without the MPSR concern is

$$\hat{q}_R(w,\lambda) = (r-w)B/(r-\lambda w).$$

The expected profits of the retailer and the supply chain are consequently, respectively,

$$E\pi_R[\hat{q}_R(w)] = (r-w)^2 B/2(r-\lambda w), \text{ and}$$

$$E\pi_{SC}[\hat{q}_R(w)] = (r-w)^2 B[2(r-c)(r-\lambda w) - r(r-w)]/2(r-\lambda w)^2$$

.

Now, with the MPSR concern, the retailer requires $E\pi_R(\hat{q}_R) \geq k \cdot E\pi_{SC}(\hat{q}_R)$, which is equivalent to the following quadratic inequality after simplification

$$\lambda w^2 - w\big((1+\lambda)r + k[r - 2\lambda(r-c)]\big) + r[r - k(r-2c)] \geq 0. \qquad \text{(A1)}$$

Let $H(w) = \lambda w^2 - w\big((1+\lambda)r + k[r-2\lambda(r-c)]\big) + r[r-k(r-2c)]$. Then, after simplification, the discriminant of the quadratic equation $H(w) = 0$ is actually

$$\Delta_H(k,\lambda) = \big(k[r-2\lambda(r-c)] + (1-\lambda)r\big)^2 + 8k\lambda(1-\lambda)r(r-c).$$

It can be easily observed that $\Delta_H > 0$, and therefore there exist two distinct roots for $H(w) = 0$, namely,

$$w_{CP}(k) = \frac{1}{2\lambda}\left((1+\lambda)r + k[r - 2\lambda(r-c)] - \sqrt{\Delta_H(k,\lambda)}\right), \text{ and}$$

$$w_R^+ = \frac{1}{2\lambda}\left((1+\lambda)r + k[r - 2\lambda(r-c)] + \sqrt{\Delta_H(k,\lambda)}\right).$$

Correspondingly, to satisfy the condition (A1), it requires $w \le w_{CP}(k)$ or $w \ge w_R^+$.

In the following, it will show that $c < w_{CP} < r < w_R^+$. First, as $\lambda > 0$ and $H(w_{CP}(k)) = H(w_R^+) = 0$, then $H(w) < 0$ for all $w \in (w_{CP}(k), w_R^+)$ and $H(w) > 0$ when $w < w_{CP}(k)$ or $w > w_R^+$. Second, it can be easily verified that

$H(c) = (r-c)(r(1-k) - \lambda c + 2k\lambda c) > (r-c)((1-k)(1-\lambda) + k\lambda)c > 0$ and

$H(r) = 2rk(r-c)(\lambda - 1) < 0$. Combining these yields $c < w_{CP}(k) < r < w_R^+$.

Returning to the conditions of (A1), as $w_R^+ > r$, and this exceeds the feasible range of w ($w \in [c, r]$), the condition $w \ge w_R^+$ is infeasible. Hence to satisfy (A1) requires $w \le w_{CP}(k)$.

For (c):

When $w > w_{CP}(k)$, the retailer's expected profit cannot achieve her MPSR requirement. As a result, she will reject the contract and order nothing; therefore, $q_R^*(k|w,\lambda) = 0$. When $w \le w_{CP}(k)$, the retailer's MPSR requirement is satisfied and she will accept the contract. The optimal order quantity to maximize her expected profit is $q_R^*(k|w,\lambda) = \hat{q}_R(w,\lambda)$. (Q.E.D.)

C1.2. Proof of Lemma 5.1

To satisfy the supplier's participation constraint, $E\pi_S(w) \geq 0$ must hold. After simplification, it is equivalent to the following quadratic inequality,

$$\lambda w^2 - w(2r - \lambda r + 2\lambda c) + 2cr \leq 0. \tag{A2}$$

Let $\hat{H}(w) = \lambda w^2 - w(2r - \lambda r + 2\lambda c) + 2cr$. After some manipulation, the discriminant of the corresponding quadratic equation is given by

$\Delta_{\hat{H}} = 4(1-\lambda)r^2 + \lambda^2(r-2c)^2$, which is obviously greater than zero.

Thus, the quadratic equation $\hat{H}(w) = 0$ has two distinct real roots, w_S^- and w_S^+, which are,

$$w_S^- = \frac{1}{2\lambda}[(2r - \lambda r + 2\lambda c) - \sqrt{4(1-\lambda)r^2 + \lambda^2(r-2c)^2}], \text{ and}$$
$$w_S^+ = \frac{1}{2\lambda}[(2r - \lambda r + 2\lambda c) + \sqrt{4(1-\lambda)r^2 + \lambda^2(r-2c)^2}].$$

Correspondingly, inequality (A2) requires $w_S^- \leq w \leq w_S^+$.

In the following, it will show that $c < w_S^- < r < w_S^+$. First, as $\lambda > 0$ and $\hat{H}(w_S^-) = \hat{H}(w_S^+) = 0$, $\hat{H}(w) < 0$ for all $w \in (w_S^-, w_S^+)$ and $\hat{H}(w) > 0$ for $w < w_S^-$ or $w > w_S^+$ are obtained. Second, it can be easily verified that $\hat{H}(c) = \lambda c(r-c) > 0$ and $\hat{H}(r) = 2r(r-c)(\lambda - 1) < 0$. After combining these, $c < w_S^- < r < w_S^+$ is obtained.

As $c \leq w \leq r$, the supplier's participation constraint becomes $w_S^- \leq w \leq \min\{w_S^+, r\} = r$. Theorem 5.1 shows that the retailer's participation constraint is $w \le w_{CP}(k)$. Thus the supplier's participation constraint can never be satisfied if $w_{CP}(k) < w_S^-$. Both the retailer and the supplier will participate in the contract only when $w_S^- \le w \le \min\{w_{CP}(k), r\} = w_{CP}(k)$. (Q.E.D.)

C1.3. Proof of Lemma 5.2

The second derivative of $E\pi_S(w)$ with respect to w can be derived as the following expression after some simple mathematical manipulation,

$$\frac{d^2 E\pi_S(w)}{dw^2} = -\frac{(1-\lambda)rB}{(r-\lambda w)^2}\left(\lambda w[(1-\lambda)r + 2\lambda c] + 2(1-\lambda)r^2 - 2\lambda cr\right).$$

a) Then it can be easily derived that $d^2 E\pi_S(w)/dw^2 < 0$ iff

$w > \dfrac{2r(\lambda r - r + \lambda c)}{\lambda(r - \lambda r + 2\lambda c)} \cong \overline{w}$.

b) A sufficient condition to guarantee $d^2 E\pi_S / dw^2 < 0$ is $\overline{w} < 0$. As $r - \lambda r + 2\lambda c > 0$, $\overline{w} < 0$ implies that $\lambda r - r + \lambda c < 0$, which requires $\lambda < r/(r+c)$. (Q.E.D.)

C1.4. Proof of Theorem 5.2

a) This is the direct result required by the supplier's participation constraint.

b) With the assumption of $\lambda < r/(r+c)$, $E\pi_S(w)$ is strictly concave in w and the optimal wholesale price (without considering whether it is within the feasible range) is given by $\hat{w}_S = \arg_w\{dE\pi_S(w)/dw = 0\}$. As $E\pi_S(w)$ is strictly concave and attains its maximum at $\hat{w}_S$, $E\pi_S(w)$ increases in w for $w < \hat{w}_S$. Now, if $w_S^- \le \hat{w}_S < w_{CP}(k)$, then $\hat{w}_S$ is both the feasible and optimal solution; but, if $\hat{w}_S \ge w_{CP}(k)$, then the supplier can only set the wholesale price at $w_{CP}(k)$, which yields the highest profit for him, while still allowing the retailer to participate in the contract. (Q.E.D.)

C1.5. Proof of Theorem 5.3

$\hat{w}_{SC}$, stated in Equation (5.12), is the channel coordinating wholesale price that makes $q_R^*(k|w,\lambda) = q_{SC}^*$, without considering the retailer's acceptance constraint. If the retailer has an MPSR concern, to have $\hat{w}_{SC}$ fall within the feasible range, $\hat{w}_{SC} \le w_{CP}(k)$ is needed, which can be further simplified as

$$(r-\lambda r+\lambda c)\sqrt{A^2(k,\lambda)-4\lambda r[r-k(r-2c)]} \le (r-\lambda r+\lambda c)A(k,\lambda)-2\lambda cr\,, \qquad \text{(A3)}$$

where $A(k,\lambda)=(1+\lambda)r+k(r-2\lambda r+2\lambda c)$.

Note that the left-hand side is positive, and it can be shown that the right-hand side is also positive when $\lambda \le 1/2$. Squaring both sides and after simplification yields

$$k < (1-\lambda)r/(r-\lambda r+\lambda c)\,. \qquad \text{(Q.E.D.)}$$

Appendix C2 - Supplementary Tables

Table A. Summary of average wholesale price under different MPSRs (hypothesis 2)

	Average w		
	Results from theoretically optimal decisions	Results from experiments	
		Second 30 rounds with contract acceptance	All 60 rounds
MPSR=0	18.9	17.1 (2.29)**	16.5 (2.87)**
MPSR=0.1	18.9	16.9 (1.18)**	16.6 (1.85)**
MPSR=0.3	18.9	15.7 (1.10)**	15.6 (1.56)**
MPSR=0.5	15.0	14.0 (0.588)**	13.8 (1.19)**
MPSR=0.75	12.1	11.8 (0.45)**	12.2 (1.95)**
MPSR=0.9	10.7	11.2 (0.50)**	11.1 (2.69)**

Note. ** $p < 0.01$. Standard deviations are reported in parentheses.

Table B. Summary of supply chain profit performance under different MPSRs (hypothesis 3)

	Results from experiments	
	All rounds with contract accepted	All 60 rounds
MPSR=0		
Retailer's profit	713.4 (938.4)	713.4 (938.4
Supplier's profit	755.1 (443.7)	755.1 (443.7)
Supply chain profit	1468.5 (1229.9)	1468.5 (1229.9)
MPSR=0.1		
Retailer's profit	697.6 (840.1)	688.4 (836.3)
Supplier's profit	849.0 (393.1)	834.1 (405.5)
Supply chain profit	1546.6 (1162.4)	1522.6 (1168.3)
MPSR=0.3		
Retailer's profit	724.0 (924.0)	790.8 (960.7)
Supplier's profit	847.2 (442.9)	794.9 (464.8)
Supply chain profit	1571.3 (1313.9)	1585.7 (1339.4)
MPSR=0.5		
Retailer's profit	1074.3 (1114.3)	1022.0 (1110.5)
Supplier's profit	649.3 (438.4)	615.3 (452.3)

Supply chain profit	1723.7 (1507.0)	1637.3 (1517.4)
MPSR=0.75		
Retailer's profit	1468.5 (1371.1)	1159.9 (1336.2)
Supplier's profit	283.9 (421.1)	224.7 (388.5)
Supply chain profit	1752.5 (1765.4)	1384.6 (1699.5)
MPSR=0.9		
Retailer's profit	1771.4 (1513.7)	1374.0 (1475.1)
Supplier's profit	-54.2 (388.8)	-34.5 (341.4)
Supply chain profit	1717.2 (1873.1)	1339.5 (1749.1)
Note. Standard deviations are reported in parentheses.		

Appendix C3 - Experiment Instruction

You are about to participate in two games in which you will earn experimental dollars based on your decisions. The amount of experimental dollars you earn will be converted into real HK dollars at the end of the experiment according to the exchange rate formula. If you follow the instructions carefully and make good decisions, you could earn a considerable amount of money.

You are a supplier who produces a single item at a unit production cost of 8 dollars. The market price is 25 dollars per unit (retail price). You are offering an MMP to a retailer, and you need to decide the price at which you will sell the product to a retailer (wholesale price); the markdown price is 50% of the wholesale price. Your task is to choose a supply contract parameter, called the wholesale price.

In this supply chain, the retailer will order from you (the supplier) in response to your offered wholesale price before he knows for certain the quantity demanded by the consumer market. However, at the time of his order decision, you (the supplier) and the retailer (the computer) have some knowledge regarding the demand distribution. Specifically, you know that demand will be between 0 and 300 units, with each demand realization in this range being equally likely. You need to play against a computerized retailer for 60 rounds for each game (two games in total).

The main task in this experiment is the choice of a supply contract. Prior to the retailer's order decision, you (the supplier) need to decide the wholesale price ($8 \le w \le 25$). If the retailer rejects your contract, you will get zero profit; if the retailer accepts your wholesale price, you will have to refund to the retailer for any leftover quantity at the end of the retailer's selling season at a markdown price. Thus, your profit under the accepted contract case depends on not only the retailer's ordering quantity, but also on the realization of random demand at the retailer's end customer market.

<u>Retailer's Decision 1</u>: The contract is rejected. Your profit = 0

<u>Retailer's Decision 2</u>: The contract is accepted and one of the following scenarios will apply.

If Demand $<$ Order quantity (over-stocking at retailer)

Your profit (as a supplier) = wholesale price $\times$ Order Quantity $- 8 \times$ Order Quantity $- 0.5 \times$ wholesale price $\times$ (Order Quantity $-$ Demand).

If Demand $\geq$ Order quantity (under-stocking at retailer):

Your profit (as a supplier) = wholesale price $\times$ Order Quantity $- 8 \times$ Order Quantity

<u>How You Will Be Paid</u>

Your earnings in this session consist of two components: the show-up fee and the performance-based fee. The show-up fee is HKD40, whereas the performance-based fee depends on how you play the game. Specifically, you will earn experimental dollars based on your own decisions. The amount of the experimental dollars you earned will be converted to real HK dollars at the end of the experiment according to the exchange rate specified in the briefing session. Your total earnings (round off to the nearest HKD10) will be paid to you in cash at the end of the session.

Although it is highly unlikely, you may incur a loss in the game. Any loss will be deducted from the HKD40 show-up fee.

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