Operations optimization and contracting coordination for behavioral supply chain with typical social preferences

Tengfei Nie

ÉCOLE CENTRALE DES ARTS
ET MANUFACTURES
« ÉCOLE CENTRALE PARIS »

THÈSE

présentée par

M. Tengfei NIE

pour l'obtention du

GRADE DE DOCTEUR

Spécialité : Génie Industriel

Laboratoire d'accueil : Laboratoire Génie Industriel

SUJET:

Operations Optimization and Contracting Coordination for Behavioral Supply Chain with Typical Social Preferences

soutenue le 22 Janvier 2015

devant un jury composé de :

M. BILLAUT Jean-Charles	Professeur, Université de Tours	**Rapporteur**
M. SHU Jia	Professeur, Southeast University	**Rapporteur**
M. JEMAI Zied	Professeur, Ecole Nationale d'Ingénieurs de Tunis	**Examinateur**
M. YU Yugang	Professeur, University of Science and Technology of China	**Examinateur**
M. CHU Chengbin	Professeur, École Centrale Paris	**Directeur de thèse**
M. LIANG Liang	Professeur, University of Science and Technology of China	**Directeur de thèse**

Operations Optimization and Contracting Coordination for Behavioral Supply Chain with Typical Social Preferences

Tengfei NIE

January 17, 2015

Acknowledgements

How time flies! Six years of successive master-doctor program pass as quickly as a galloping horse flashes before my eyes. Looking back on these years' experience, I feel very fruitful and meaningful. As my thesis is approaching to complete, I would like to thank those people who help me a lot. My deepest gratitude goes first and foremost to Professor LIANG Liang from School of Management (SOM), University of Science and Technology of China (USTC) and Professor Chengbin Chu from LABORATOIRE GENIE INDUSTRIEL (LGI), Ecole Centrale Paris (ECP), who are the supervisors of my PhD thesis. Both Professors are so easy-going and gracious. They are noted for their profound knowledge, quick thinking and meticulous attitude to academic research, based on which they set a good example for my whole life. They remind me of keeping the pace of the times all the time, combining theory and practice and retaining pioneering spirit of innovation. They consider the innovation as the most important element of academic research and make me realize what is the real academic study and its meaning, which would play a guiding role in my future learning and life. As the authority in the domain of scheduling and algorithm, Professor Chengbin Chu revises my manuscript personally. He read them word by word and correct errors carefully, even typos, which gives me a deep impression.

I would thank Professor BILLAUT Jean-Charles from Université de Tours, and Professor SHU Jia from Southeast University for having accepted to spend their valuable time in reviewing my work and providing review reports. I am also honored by their participation in the defense committee. Many thanks to Professor JEMAI Zied from Ecole Nationale d'Ingénieurs de Tunis for having accepted to take part in the defense committee, which honors me very much.

My deepest gratitude also goes to Associate Professor DU Shaofu from SOM of USTC for his constant encouragement and guidance. He walked me through all the stages of the writing of this thesis. Without his consistent and illuminating instruction, this thesis could not have reached its present form. As his first student, Doctor DU really helps me a lot and creates many good opportunities for me, including the opportunity of studying abroad. Though he has a wide knowledge and a strong academic ability, he is really a very modest man. He is also a popular fellow among colleagues. I learned from him a lot not only in academic knowledge but also in the way how to get on well with other people. It's him who led me to the academic road.

In addition, I would like to express my heartfelt gratitude to Professor YU Yugang, who also comes from SOM of USTC. He helps me a lot so that I can go to Paris to get further education abroad. I really admire him for his sharp insight and rigorous attitude to research. I am also greatly indebted to Professor YANG Feng of USTC, who was the teacher in charge of our class when I was a master. At that time, I found it is difficult to continue my study when I just came in USTC and I wanted to give up, it's him who gave me a lot of encouragement so that I can persist in my research till today. I never gave up no matter what difficulties I was facing thereafter. Furthermore, I would like to express my gratitude to teacher DONG Junfeng. He taught me how to use software of calculation and some basic knowledge of this domain when I was a beginner. Thanks also go to my good friends and classmates, Guo Xiaolong, Yang Chenchen, Du Chan and Zhou Zhixiang. They all helped me to make progress every day, including in study and in daily life.

Special thanks should go to my friend FANG Zhou, who was my classmate in master stage. After graduated from USTC as a master, he chose to work as a teacher in another university while I chose to continue to get my PhD degree. Though we were not in the same city, or later even not in the same country, we kept in touch with each other all the time. Whenever I was confronted with any problems, I discussed with him by phone or through internet. He spent a lot of time in checking the complicated calculations and formulae for me. More importantly, I was deeply touched by his altruistic spirit. I wanted to add him to the paper as one of the co-authors, but he refused politely since he believed that his contribution is not enough.

I would like to thank the dean from LGI of ECP, Bocquet Jean-Claude. He provided us with a very good condition to study. Thank all the staff of the laboratory, including Delphine, Sylvie, Carole, Corine. All these French ladies were so nice and offered a big convenience for all the students. I also owe my sincere gratitude to those foreign friends and fellows from ECP. All of them were very nice and I got along well with all of them. We not only talked about the research, but also our own culture, which broadened my horizon and enriched the boring study abroad and at the same time, my English and French improve a lot. They are handsome guys, Toufic and Karim, who worked in the same office with me; beautiful girls, Denis and Anastasia; smart guy, Baris; French boy, Camille; African brother, Alex. A big thanks to Program Cai Yuanpei of the China Scholarship Council (No. 26058PL) for subsidizing my two-year study abroad.

I also owe a special debt of gratitude to my colleague, HONG Zhaofu. He took scrupulous care of me and cook for me when I was ill during studying period in France, which makes me feel at home even in a foreign country. I have to thank another colleague, CAO Yu, who helped me as an interpreter to go through all the formalities since my French was poor as a new comer in France. Thank other Chinese guys, they are ZHONG Yueru, CHEN Yuanyuan, MAI Zhaohuan, ZHANG Yufang, XIONG Shiyun, LI Zongshen, LIU Jie, FANG Yiping, WANG

Tairan, XU Xiao, LV Pin, YANG Yaqin, YE Yun. We spent a lot of wonderful time together and I will never forget it. Thanks also go to HE Biyu and HUANG Rongji for helping me correct the mistakes and typos of this thesis.

Thank all my schoolmates, friends and colleagues who cared about me and helped me. It's you guys who shared my unhappiness and happiness, which makes me much stronger and walk more steadily and confidently on the road of life.

Finally, I am forever indebted to my family, especially my grandparents, my parents and my uncle, for their unconditional support and great confidence in me all through these years. Their unending and unselfish love is the greatest momentum of my study and work. I would make persistent efforts to live up to their expectations and reward those people who love me and those whom I love most!

Abstract

This thesis studies how to incorporate typical social preferences, such as fairness concerns and reciprocity, into the context of supply chain. The impacts of theses social preferences on the supply chain's decisions, channel efficiency and coordination are investigated. Specifically, it focuses on three important questions as follows: 1, what are the differences between the conventional channel and the behavioral channel (e.g., fairness-concerned channel and reciprocal channel)? 2, how do these behavioral factors influence the decisions of the supplier and the retailer in the supply chain? 3, what effects have these social preferences on the coordination of the channel and its efficiency? In order to answer these questions, two models of behavioral operations are formulated. A newsvendor model for a dyadic supply chain with Nash bargaining fairness concerns is built first. In this model, a supplier plays Stackelberg game with a retailer who faces stochastic demand. Nash bargaining solution is used as fairness reference to formally depict perceptively fair compromise, which is a new perspective to study fairness concerns in a supply chain. Then a similar dyadic channel in which a retailer and/or a supplier have a preference for reciprocity is investigated, but the retailer is facing deterministic demand. In this model, the impact of intention is studied within the context of supply chain for the first time. Some interesting and valuable managerial insights are drawn by analyzing the two behavioral models. For example, fairness concern does have great impact on the difficulty of coordinating a channel. In addition, the dyadic channel with reciprocity can be coordinated by using a constant wholesale price, which implies that the problem of double marginalization is not necessary to be present all the time.

Keywords: Behavioral Operations, Supply Chain Management, Social Preference, Wholesale-price Contract, Fairness Concern, Status Seeking, Nash Bargaining, Reciprocity, Intention

Résumé

Cette thèse étudie l'incorporation des préférences sociales typiques, telles que le souci de justice et la réciprocité, dans la chaîne logistique. Les impacts de ces préférences sociales sur la prise de décisions dans la chaîne logistique, sur l'efficacité et la coordination du canal de distribution sont étudiés. Plus spécifiquement, la thèse se focalise sur trois questions essentielles ci-dessous : 1. Qu'est-ce qui différencie un canal conventionnel d'un canal comportemental qui prend en compte la justice et/ou la réciprocité par exemple ? 2. Comment ces facteurs comportementaux influencent-ils la prise de décisions du fournisseur et du distributeur dans la chaîne logistique ? 3. Quels effets ont ces préférences sociales sur la coordination du canal de distribution et sur son efficacité ? Afin de répondre à ces questions, nous développons deux modèles d'opérations comportementales. Nous construisons d'abord un modèle de vendeur de journaux pour une chêne logistique dyadique avec prise en compte de justice dans un processus de négociation de Nash. Dans ce modèle, un fournisseur joue un jeu de Stackelberg avec un distributeur qui doit faire face à une demande aléatoire. La solution de Nash est utilisèe comme référence de justice pour formellement décrire un compromis perçu comme juste, ce qui constitue une nouvelle manière de traiter la justice dans une chaîne logistique. Ensuite nous étudions un canal de distribution similaire mais où le fournisseur et le distributeur ont une préférence pour la réciprocité et la demande est supposée déterministe. Dans ce modèle, l'impact de l'intention dans une chaîne logistique est étudié pour la première fois. Des analyses approfondies de ces modèles comportementaux nous permettent de tirer des aperçus managériaux intéressants, comme par exemple le fait que le souci de justice joue un rôle important sur la difficulté de coordonner un canal de distribution. Nous avons démontré qu'un canal dyadique avec prise en compte de réciprocité peut être coordonné en utilisant un prix de gros constant, ce qui signifie que le problème de double marginalisation ne se pose pas nécessairement tout le temps.

Mots clés : Opérations comportementales, Management de la chaîne logistique, Préférences sociales, Contractualisation basée sur le prix de gros, Justice, « Quête de prestige », Négociation de Nash, Réciprocité, Intentions

Contents

*This chapter is primarily referenced from: Shaofu Du, **Tengfei Nie**, Chengbin Chu, and Yugang Yu (2014). Newsvendor model for a dyadic supply chain with nash bargaining fairness concerns. International Journal of Production Research, 52(17): 5070-5085. DOI: 10.1080/00207543.2014.895446.

*This chapter is primarily referenced from: Shaofu Du, **Tengfei Nie**, Chengbin Chu, and Yugang Yu (2014). Reciprocal supply chain considering intention impact. European Journal of Operational Research, 239(2): 389-402. DOI: 10.1016/j.ejor.2014.05.032.

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Research Background

This thesis focuses on behavioral study of hot issues in OM - supply chain contract and coordination. Specifically, it is going to study the influences of some typical social preferences on the decisions, efficiency and coordination in supply chains. The core of these preferences is fairness, which captures the hot issue in channels. Relevant results will be conducive to understand the deep reasons for conflict between members.

Since the Nobel Prize of Economics was awarded in 2002 to Daniel Kahneman and Vernon L. Smith for their outstanding work on the psychology of judgement and decision-making, behavioral economics and experimental economics, Behavioral Decision Theory has occupied a very important place in economics and challenges the traditional economic theory. This Behavioral Decision Theory has been applied to many other relevant fields quickly, such as Operations Management (OM). The reason why traditional OM results are often not directly applicable to real-world scenarios is that most standard theoretical models in OM fail to account for the way human behavior affects operations. Therefore, an increasing body of literature in behavioral operations has emerged in the past two decades and there have been many interesting findings in this area, which are continuously changing the way researchers address OM problems (please refer to Bendoly et al. (2006) for an overview of behavioral operations management (BOM) findings).

Traditional models of economics and operations management are based upon the assumption that people are fully rational or can be induced to behave rationally, which implies that they can distinguish signal from noise and their decision-making process is not affected by cognitive biases or emotions through incorporating all relevant alternatives and variables (Gino and Pisano, 2008). With the help of experiments of economics and questionnaire survey, researchers found a lot of anomalies which are in conflict with the assumptions of traditional economics models. Behavioral economists extract and summarize many individual decision making biases under the scenarios of uncertain judgement and social preferences describing players' behavior in their social contexts. Current main studied behavioral factors in BOM refers to Figure 1.1. An important characteristic of BOM is its interdisciplinarity which combines operations management with those behavioral factors found based on anomalies, such as reference dependence and loss aversion, hyperbolic discounting, regret theory and social preference theory. This thesis focuses on social preferences, specifically, the preference for reciprocity and the preference for fairness concern with status seeking.

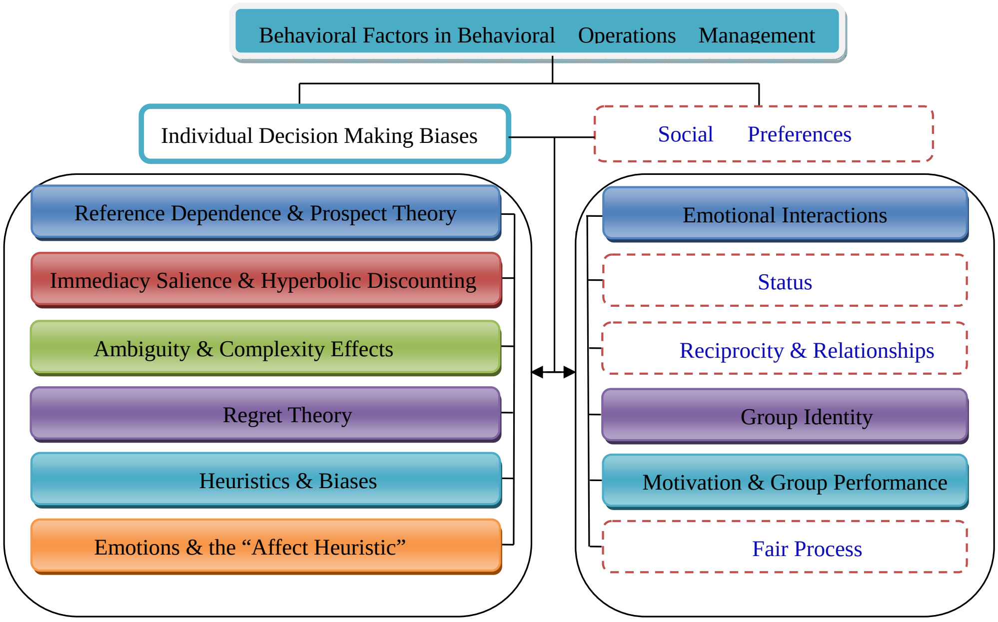

Figure 1.1: Main behavioral factors studied in BOM (according to Loch and Wu (2007))

A great number of experiments such as ultimatum game, gift-exchange game, public goods game, indicate that people frequently choose actions that do not maximize their monetary payoffs, which violates traditional assumption of "self-regarding preferences" characterized by an exclusive concern about one's own material payoff. Models of self-regarding preferences capture behavior quite well in many contexts, but there is now a large body of literature that reports systematic inconsistencies with the implications of the self-regarding preferences models (Cox and Deck, 2005). Social preferences are important behavioral factors ignored by conventional OM theory. They can be regarded as an important complement to the theory of "self-regarding preferences". Typical social preferences includes fairness concern and reciprocity, both of which are preferences for fairness.

The topic of fairness is very popular in the practice of operations management. Cui et al. (2007) enumerate many studies in economics and marketing, which have well-documented cases where fairness plays an important role in developing and maintaining channel relationships. Furthermore, there are some cases where both manufacturers and retailers sacrifice their own margins for fairness concerns (Olmstead and Rhode, 1985; Kumar, 1996; Scheer et al., 2003). There are also some examples in which the channels were broken because the fairness concerns of one side were neglected by other sides. For instance, the largest socks manufacturer of China, *Langsha Group*, decided to terminate cooperation with Wal-Mart in 2007 because it thought the benefit allocation is unfair. Another example involves an important distributor of P&G, *Xuzhou Wanji Trading of China*, who determined to abort its transaction with P&G in 2010 because P&G was regarded as grabbing too much profit, which was also considered to be unfair. The research in the past three decades shows that “there is a significant incidence of cases in which firms, like individuals, are motivated by concerns of fairness” in business relationships, including channel relationships (Kahneman et al., 1986a).

However, operational studies on fairness is still in its early stage. Inadequate effort so far has been paid to incorporate fairness into supply chain decision. Cui et al. (2007) analyze fairness concern in a conventional dyadic channel to investigate how fairness may affect channel coordination. The result shows that the supplier can use a simple constant wholesale price above her [1] marginal cost to coordinate this channel in the form of maximizing both profit and utility. Their analyses are based on deterministic demand. Ho and Zhang (2008) confirm the existence of fairness preference in the setting of supply chain. They put forward descriptive utility function rather than analyze the effects of fairness on coordination in detail. Pavlov and Katok (2009) investigate the impacts of fairness on channel coordination combining theory and empirical research. They assume that fairness concern is private information and explain many related questions such as refusal and low efficiency. They conclude that the main reason for which those contracts can coordinate the channel in theory while fail in practice is due to incomplete information. Fehr and Schmidt (2006) provide a comprehensive overview of recent papers based on social preference where players not only care about their own material payoff but also about other things like fairness.

When talking about fairness, we often only focus on the outcome of an allocation derived by accomplishing a trading collaboratively. However, some studies show that intention underlying an action is a nonnegligible behavioral factor as well, sometimes even plays a more important role. For instance, Kahneman et al. (1986b) investigate the fairness as a constraint on profit seeking. Their result shows that a hardware store is considered unfair to raise the price because it takes advantage of the short-run increase in demand associated with a blizzard. However, their result of questionnaire implies that the action of increasing retail price is acceptable because the local grocer has bought the usual quantity of lettuce at a price that is 30 cents per head higher

[1] In the context of supply chain, “she” and “he” are used to represent the supplier and the retailer respectively throughout this thesis.

than normal due to the increase in wholesale price is caused by a transportation mixup. The two actions have the same consequence - rise in price, while the responses are quite different. This result implies that the opponent's intention will also affect individuals' decisions and it even plays a dominant role sometimes. The consideration of intention is a very important part of reciprocity theory.

Hitherto many models have been built based on social preferences of fairness. Generally, they can be classified as either outcome-based or intention-based. Intention-based fairness and outcome-based fairness are two important concepts of fairness, the former emphasizes the importance of intentions behind actions while the latter tends to evaluate the utility by comparing two or more outcomes of actions. Therefore, the two concepts are accordingly classified into reciprocity preference and inequality-aversion preference by the behavioral economists, respectively. These two categories of models are different from each other in the following two aspects: (1) In the models of reciprocity, both consequence and intention are simultaneously considered. In many policy-making decisions which involved game theory, the player wants to figure out the underlying intention behind the consequence as a basis for formulating policy. However, the decision-makers focus on outcome only in the outcome-based models. (2) In the outcome-based models, only when the follower has the possibility of reducing this inequality will he punish the other party. In the reciprocity models, however, the decision-makers reciprocate or punish their partners on the basis of perception of kindness or unkindness from them.

Loch and Wu (2007) believe that with appropriate extensions of traditional rational choice and game theory models to incorporate decision biases, emotional or social preferences, and cultural norms, mathematical models can guide empirical testing in behavioral OM just as well as in OM at large. Since traditional OM theories and models neglect those important and indispensable behavioral factors which would cause systematic deviations, it would be meaningful to incorporate them in OM context.

In this thesis, individuals endowed with social preferences are willing to make material sacrifices to reward others who are kind to them, and to punish those who are not. Their motivations for doing so do not arise from any prospects of future material reward. Numerous behavioral experiments have demonstrated that these social preferences are people's significant attributes which have been neglected by traditional models. Therefore, this research is not only a complement to traditional theory, but also helpful to guide practice.

1.2 Problem Description

As discussed in the previous section and in the coming Chapters 3 and 4, the preference for fairness is significant and can not be neglected in the process of decision, especially in the context of supply chains since the members are very concerned about how to allocate profit. Therefore, conventional OM models should be amended. According to Campello et al. (2008), research needs to satisfy two criteria so that it can be classified as behavioral operations. It needs to have an operations context and at the same time, it needs to explicitly include the considerations of human behavior variables. This thesis investigates the influences of social preferences, including fairness concern and reciprocity, on the decisions of a dyadic supply chain. Two behavioral models of operations management are built to study the two problems of BOM: fairness-concerned model and reciprocity model. In order to show the focus of the thesis and to better solve the two above-mentioned problems, several sub-problems are proposed in each model. Then the thesis is going to list these sub-problems one by one and give them some explanations (please refer to Figure 1.2 for analytical framework).

Fairness-concerned Model with Nash Bargaining

This model studies a dyadic supply chain in which a single supplier sells its product to consumers through a single retailer with stochastic demand. The two members play Stackelberg game in the following sequence: for expositional convenience, the supplier offers the retailer a wholesale-price contract; the retailer chooses to accept or reject it; if the retailer accepts it, an order quantity is submitted to the supplier; before the selling season comes, the supplier produces and delivers the products to the retailer; season demand occurs; transfer payments are made between the two firms according to the agreed contract. If the retailer rejects the contract, no game is played and each firm gets nothing. Thus, the supplier acts as a leader and the retailer acts as a follower in this game. Simultaneously, wholesale-price contract operates with forces compliance regime which means the supplier never chooses to deliver less than the retailer's order since the costs for doing so are sufficiently high. The biggest difference between this behavioral model and traditional models is that both members are assumed to have the preference of status seeking with fairness concerns. This fairness reference is more applicable since it reflects the two parties' abilities and contributions.

1. How to build the model in which the members have the preference for fairness concern with status seeking?

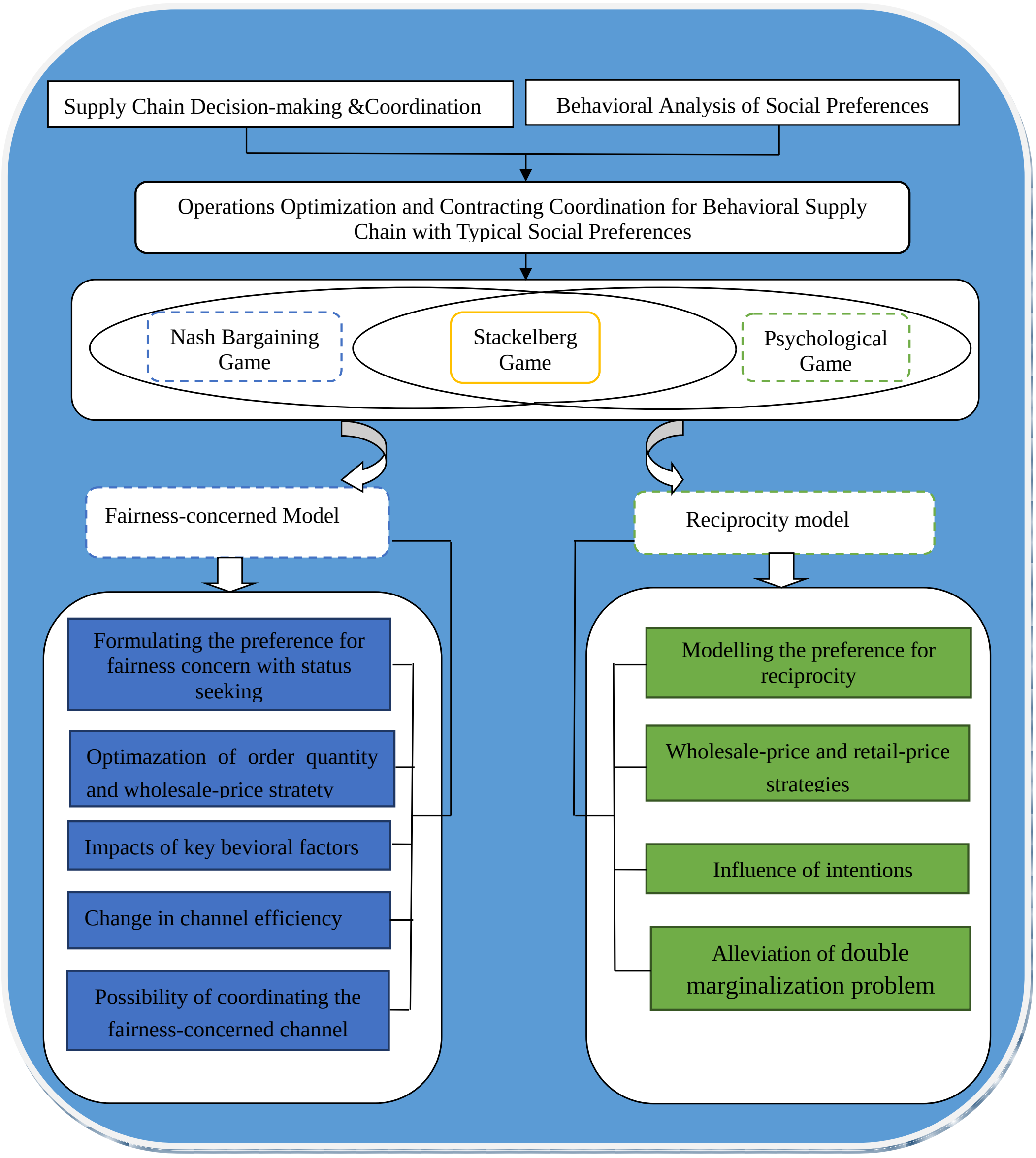

Figure 1.2: Analytical framework for fairness-concerned model and reciprocity model

This is a very common problem for behavioral operations. It is often the first and the most important question, that is, how to incorporate the behavioral factors into specific context of operations so that you can study their impacts on the decisions? The most common way to express the decision-maker's utility function is that it equals the conventional profit term plus the behavioral utility term.

In traditional models, the solely goal of the decision-maker is to make optimal decisions to maximize the profit term. Therefore, the main difference between traditional OM models and behavioral OM models lies in the additional behavioral utility term. In fairness-concerned model with Nash bargaining, the behavioral utility term needs to reflect the decision-maker's preference for fairness. The solution derived from Nash bargaining game is regarded as the most suitable standard that best reflects the decision-makers' (including the supplier and the retailer) fairness reference, the detailed reason for this can be found in Chapter 3. Furthermore, a gain less than the fairness reference will reduce the utility. This framework of fairness implies the decision-maker is accompanied with a preference for status seeking, or we can say status (status-seeking) preference.

2. How should the retailer make his order quantity and the supplier price her products?

As the first mover, the fairness-concerned supplier prices her products first, i.e., unit wholesale price. Seeing the wholesale price, the fairness-concerned retailer makes his optimal order quantity. According to backward induction, the retailer's decision should be analyzed first so that we can find his best response function, based on which the supplier optimally prices her product. In the process of this game, if the retailer perceives that the wholesale price is not fair (may be too high for him), he will lower his order quantity, even if this action leads to a lower channel efficiency and thus, both parties' payoffs decrease. The supplier knows this causality between her decision and the final payoff, but she may take the risk of gaining more since she has status preference. This status preference is not in conflict with fairness concern because it is reasonable to obtain more only if everybody gets what he/she deserves.

3. How key behavioral factors influence the retailer's and the supplier's decisions?

These behavioral factors mainly include both parties' fairness concern parameters, and Nash bargaining powers. Through analyzing the impacts of these parameters on the supply chain's decisions, the effects of fairness concerns on the channel efficiency and coordination will be more clear. It would be also helpful to understand the reasons of conflicts between them.

4. What would be the channel efficiency compared with that of conventional channels?

The influences of the behavioral factors on dyadic channel efficiency needs a reference. Thus, the decisions of the conventional channels are always given first as a benchmark. By comparing the efficiencies between the two channels, we can find that the channel efficiency decreases after incorporating behavioral factors. Detailed results and relevant reasons are given in Chapter 3.

5. Does 'double marginalization' problem becomes more severe when both members have this behavioral preference?

Spengler (1950) is the first scholar who proposed the concept of 'double marginalization';

the coordination failure always exists in this serial supply chain because there are two margins and neither member considers the whole supply chain's margin when making a decision. The problem of coordination is one of the most valuable issues in research on supply chain. The result of Chapter 3 shows that the dyadic channel is still unable to be coordinated with simple wholesale-price contract and at the same time, the whole channel efficiency goes down. Therefore, the double marginalization problem becomes worse if both members have this behavioral preference. We can't say that the fairness-concerned model is not good because it just truly reflects the practice. What we can do is to learn lessons from it and design more applicable mechanism to promote coordination between them.

Reciprocity Model

This model investigates a similar dyadic supply chain to that of fairness-concerned model except that the market demand is deterministic. Detailed notations can be found in Chapter 4. In this reciprocity model, the supplier and/or the retailer are assumed to have the preference for reciprocity, which means they reward the other party's kind actions and punish unkind ones. In order to evaluate whether an action is kind or not, the decision-maker (the supplier or retailer) has to see the outcome brought by this action and the intention behind it. Nearly all the players in models of behavioral operations are assumed to perceive whether they are treated fairly or not based on outcome. Therefore, this reciprocity model is the first one which regards intention as an important behavioral factor for both parties' decisions. Similarly, with the reciprocity model, this thesis focuses on the following four problems.

6. How to build the model in which the members have the preference for reciprocity?

Likewise, in this model, the decision-maker's (the retailer and the supplier) utility function consists of two parts: one is the traditional profit term, the other is reciprocation utility term. The reciprocation utility term is used to represent the utility that is derived from rewarding or punishing the other party. It is a product of four terms, including the weight factor, the intention factor, the outcome term and the reciprocation term. How to mathematically express the intention factor is the key part of building this utility function. Detailed explanation for every term and how they these terms operate can be found in Chapter 4. The supplier's and the retailer's utility functions can address the following important questions: how do they perceive the other party is kind or unkind? how to reward the other party's kindness and punish the unkindness? what's the percentage of utility brought by reciprocation in decision-maker's total utility?

7. How should each player make his/her decision?

Unlike fairness-concerned model, the reciprocity model focuses on the pricing decisions of the supplier and the retailer. Specifically, if the retailer perceives unkindness from the supplier, he can punish the supplier by increasing the retail price of the product, though it may be harmful to himself. This punishment brings at least two bad things for the supplier: firstly, the product of her market share decreases; secondly, it labels bad reputation to this product because its price rises to a high level without giving any understandable reasons. The supplier will punish the retailer by increasing the wholesale price as well when he believes that the retailer is unkind to her. Price cutting would be the way to reward the other party. After playing this game for many times, the prices for both parties converge to a stable status, which is called Psychological Nash Equilibrium.

8. Do intentions really play a significant role in the process of making decisions for both parties?

The identical consequences trigger different behavioral responses under different settings. This result has been tested by many experimental games, such as the ultimatum game, the gift-exchange game and reduced best-shot game. Therefore, it is necessary to consider the decision-maker's intention as well when we analyze the supply chain decisions, instead of focusing on the outcome of an action only. This model is going to incorporate the intentions into the context of a dyadic supply chain and investigate how intentions affect the decisions of the two parties through the way of psychological game. The results show that the intentions of the decision-makers do really have significant effects on their decisions. The results of this thesis show clearly that the retailer's pricing strategies are different in intention-based and non-intention-based scenarios. Furthermore, the clearness of the intentions also have impact on the retail price.

9. Is the double marginalization problem always present in a channel where both monetary payoffs and reciprocity matter?

Double marginalization problem is an important problem in conventional supply chains and it is always related to channel coordination. In the reciprocity model, four pairs of equilibria are derived after considering the intentions and one of them has the possibility to coordinate this simple channel with wholesale-price contract as long as certain prerequisites can be satisfied, which would never happen in conventional channels. Therefore, the double marginalization problem is not always present in a channel where both members care about monetary payoffs and reciprocity, which also implies that the channel efficiency can be enhanced in reciprocity model.

1.3 Research Methodology

We would like to emphasize the importance of mathematical models in the research of BOM. First, math models will produce OM theories and hypotheses for experimental studies. Many traditional OM problems such as the newsvendor problem, supply chain contracting and coordination, and the bullwhip effect, have been well structured and analyzed in mathematical models. These problems have elegant models that have been experimentally tested. The models provide testable hypotheses as well as simplified system structures that can be easily recreated in the corresponding experiment designs. Empirical tests have clearly shown that the traditional OM models are incomplete.

Until now, a sufficient number of models have been published which show that models of operations problems can be extended to include decision biases, social preferences and emotions, and even cultural norms. Mathematical models of fundamental human behaviors ranging from individual level to population were first developed in other fields, such as economics and sociology. For example, social preference models capture that human behavior can be biased by social interactions, and that people have a concern for others in addition to being self-interested. Reference-dependence and time preference have been formally modeled to capture the empirical regularities that individual's preference can be reversed by reference point and time respectively. Finally, cultural evolution models are used to study how social behaviors evolve and are transmitted in a population. The modeling techniques are well established and similar to methods already used in OM, and thus readily adaptable.

The ability of models to analyze behavior of complex systems is highly relevant for behavioral OM (most modern OM problems involve complex decision-making in decentralized systems), but they turn too hard to study without the help of models since too many interacting variables need to be controlled. Once the models have produced predictions of emergent system behavior, we can go back to experiments, or empirical studies, with a few controls. However, as a preliminary attempt, this thesis is not going so far to extend the research to experimental tests but solely focuses on modeling social preferences in the context of supply chain and reveals the managerial insights behind them.

Based on significant social preferences found in some important behavioral experiments, such as fairness concern and reciprocity, which are neglected by traditional models, this thesis is going to incorporate these preferences into similar supply chain setting (for instance, dyadic channel) to build the behavioral models and derive the equilibrium.

We first demonstrate the existence and the uniqueness (sometimes the equilibrium is not unique) of the equilibrium. Then, we will study the equilibrium intensively, including the impacts of some important factors on the members' decisions. In addition, whether the supply chain contract can coordinate the channel will be another important part. In brief, we can discuss and analyze any interesting points studied in conventional settings. Furthermore, in order to investigate the differences between the decisions of traditional models and behavioral models, the results of traditional models will be given as a benchmark. In traditional models, the decision-makers try their best to maximize the profits. However, in behavioral models, they will maximize their utilities which consider the social preferences. We can know how these social preferences affect the members's decisions and the channel efficiency by comparing the two models.

Therefore, this thesis is not going to find new social preferences by experiments but to apply those social preferences to specific supply chain settings or to further develop the existing behavioral models, for instance, Nash bargaining solution is regarded as the members' fairness reference in Chapter 3. In short, knowledge of various domains, such as Economics, Psychology, Operations, Optimization Theory and Game Theory, will be jointly employed in this study.

1.4 Research Contributions

This study makes the following contributions to the literature. First of all, we investigate fairness concerns in the supply chain from a new perspective. More attention is paid to individuals' psychological perceptions. Nash bargaining solution as fairness reference is more appropriate to formulate the individuals' fairness perception, because it focuses on the relative fairness by self-enforcingly integrating players' strength and contribution instead of the absolute fairness merely via several exogenous parameters as individuals' inherent or default properties.

Secondly, this research, to the best of my knowledge, is the first one to investigate a psychological game within the context of supply chain. Results of numerical behavioral experiments not only demonstrate that the traditional assumption of economic-man is not precise but also show that fairness concern is not enough to describe the rule of decisions. Therefore, it is necessary for us to incorporate some psychological factors such as intention into the supply chain since they have non-negligible impacts on decision making. We would like to start this work with a dyadic channel. We provide supply chain members with indications of how their intentions affect the interactions between them and derive psychological equilibria. The result of this thesis indicates that it is possible to coordinate the channel with a wholesale-price contract, which will never happen in conventional dyadic supply chains.

Finally, contribution of the work lies in the finding that the coordination of the supply chain can be achieved depends not only on the individuals' sensitivity to fairness per se but also on their perceptive fairness reference. Cui et al. (2007) show that a constant wholesale arrangement can conditionally achieve the channel's coordination while it is not true under Nash bargaining fairness. It implies that different fairness references may lead to different contract efficiency and thus derive different conclusions.

1.5 Structure of The Thesis

The remainder of the thesis is organized as follows. **Chapter 2** classifies the literature into several categories. It reviews researches relating to the context of supply chain, relevant literature of game theory, social preferences, including fairness concern and reciprocity. Furthermore, some studies in incorporating social preferences into supply chain are also reviewed. **Chapters 3 and 4** investigate the influence of the preferences of fairness concern and reciprocity on the decisions of the dyadic supply chain. Specifically, in **Chapter 3**, a new behavioral model of fairness concern based on the setting of supply chain is proposed. The two members are not only status seeking but also care about the other party's payoff. The most important contribution of this model is that Nash bargaining solution is introduced as their fairness reference for the first time. A dyadic channel in which the retailer or/and the supplier have a preference for reciprocity is analyzed in **Chapter 4**. The two players play Stackelberg game. When both of them have preferences for reciprocity, as the leader, the supplier makes optimal wholesale price to maximize her ("her" represents the supplier and "he" represents the retailer) utility which consists of profit term and reciprocal utility term. As the follower, the retailer determines his retail price as the best response to the supplier's optimal decision in order to maximize his utility. In this model, the factors, such as psychological game and intention, are introduced to the context of supply chain for the first time. **Chapter 5** concludes the thesis and provides some suggestions for the future research.

Chapter 2

Literature Review

In this chapter, a serial of literature reviews of related background and theoretical models are presented. Our research is based on the context of supply chain, so we first review the studies of newsvendor problem, dyadic channel and even some more complicated channel. Then we introduce the theory of social preference and relevant literature, especially the experiments and the models of fairness concerns and reciprocity. In addition, reviewing literature of game theory is essential. We mainly focus on Nash bargaining game, Stackelberg game and the idea of psychological game since they are the main tools for us to analyze the interaction between the two players. Finally, the literature of applying social preferences to specific settings, especially the context of operations management and supply chain, is reviewed.

2.1 Study of Supply Chain

"Supply Chain Management (SCM) deals with the management of material, information, and financial flows in a network consisting of vendors, manufacturers, distributors, and customers" (Anupindi and Bassok 1999a). A diagram of a simple one-period two-echelon supply chain is shown in Figure 2.1, based on which many complex supply chain structure can be developed. SCM has been a influential research topic in the field of Operations Management (OM). Many researchers have made contributions to a deeper understanding about underlying phenomena and causal relationships of the problems and experiences emerged from business practices, such as bullwhip effect and channel coordination. The way of research is various, including applying existing OM methods and techniques to new models for new problems, to new models for old problems that regained attention. Our research is based on the context of a supply chain, specifically, on the context of a dyadic supply chain. The literature of this field is abundant, so our review of this part is restricted within those whose topics are most closely related to our study, mainly including newsvendor problem, supply chain contracts and channel coordination.

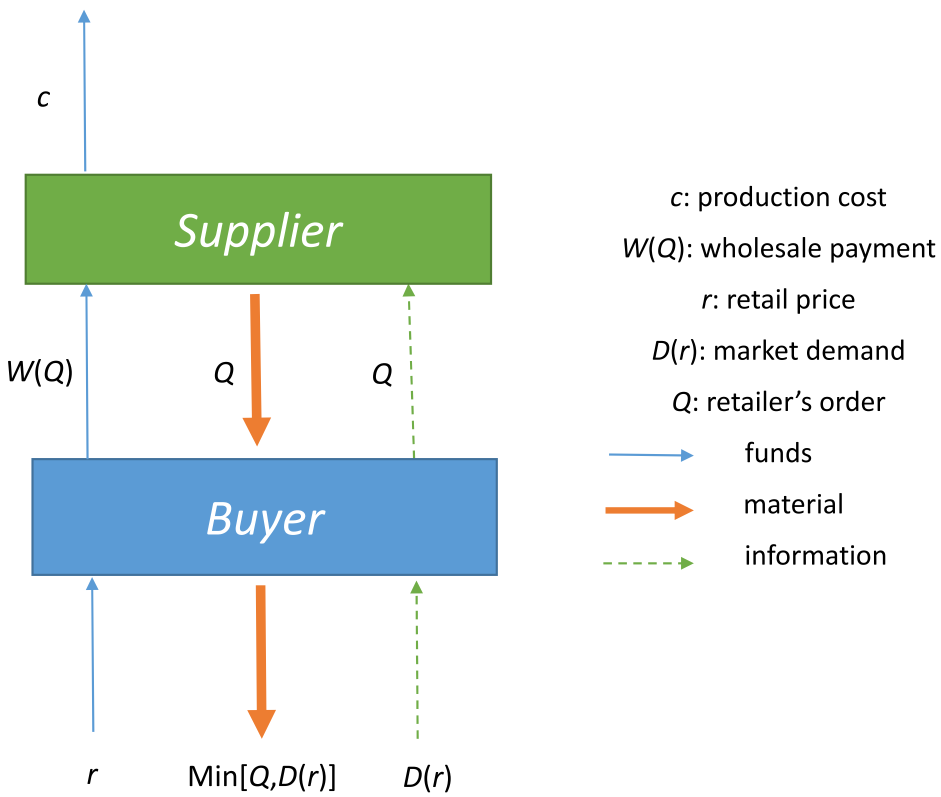

Figure 2.1: A basic one-period supply chain (borrowed from Tsay et al. (1999))

2.1.1 Newsvendor Problem

As the classical problem of SCM, the newsvendor problem has a long history and it can be retrospected to Edgeworth (1888) in which a variant is used to describe and solve a bank cash-flow problem. However, it became a serious topic and was given extensive study by academicians only when it was motivated by the war effort in 1950s. This is, in its essential, a profit maximization problem. In this problem a decision maker who faces stochastic demand for a product that becomes obsolete at the end of a single period has to decide how many units of the product to stock in order to maximize expected profit.

The classical sing-period problem (SPP), both at the manufacturing and retail levels, reflects many practice activities and is often helpful to make decision in the fashion and sporting industries (Gallego and Moon, 1993). SPP has been paid more and more attention over the past half centuries. The increasing attention can be partly explained by the trend that service industries have gained increased dominance and SPP is very applicable in both retailing and pure service organizations. For example, SPP can be used to manage capacity and evaluate advanced booking of orders in service industries such as airlines and hotels (Weatherford and Pfeifer, 1994).

There are two approaches to follow for the researchers in order to solve the SPP, i.e., minimizing the expected costs of overestimating and underestimating demand or maximizing the expected profit. The study of this thesis is mainly based on newsvendor problem and the players are going to maximize their utility formulated by incorporating behavioral factors, such as social preferences for fairness and reciprocity instead of pure profits. Specifically, in Chapter 3, we build a newsvendor model for a dyadic supply chain in which both the supplier and the retailer regard the Nash bargaining solution as their fairness reference when the demand is stochastic; a similar structure of newsvendor model is built to investigate the influences of the preferences of the supplier and the retailer for reciprocity on the channel's decisions when they are facing a deterministic demand. We are not going to review this part intensively since it is solely our research context, in stead, we focus our main attention on social preferences. Table 4.2, which borrows the classification of the extensions for SPP of Khouja (1999), is employed to show the development and the extensions of SPP.

Table 2.1: The review of the extensions for the single-period (news-vendor) problem.

Classification	Examples of Papers
A	Lanzillotti (1958);Li et al. (1991);Eeckhoudt et al. (1995);Jammernegg and Kischka (2007); Choi and RuszczyńSki (2008); Wu et al. (2009b); Chiu and Choi (2010);
B	Jucker and Rosenblatt (1985); Pantumsinchai and Knowles (1991); Lin and Kroll (1997);
C	Lau and Lau (1988); Khouja (1995); Khouja (1996); Arcelus et al. (2012); Khouja et al. (2013);
D	Ehrhardt and Taube (1987); Henig and Gerchak (1990); Parlar and Wang (1993); Ciarallo et al. (1994); Xu and Lu (2013);
E	Kumaran and Achary (1996); Hill (1997); Ridder et al. (1998); Kocabiyikoglu and Popescu (2011); Wang et al. (2012);
F	Lau and Hing-Ling Lau (1995); Khouja and Mehrez (1996); Lau and Hing-Ling Lau (1996); Özler et al. (2009); Choi et al. (2011);
G	Deuermeyer (1980); Parlar (1988); Lippman and McCardle (1997); DAS and MAITI (2007);
H	Bryan et al. (1955); Gerchak and Zhang (1992); Jönsson et al. (1993); Cheng et al. (2009);
I	Chen and Lin (1989); Chang and Lin (1991); Kouvelis and Gutierrez (1997); Cherikh et al. (2000); Lin et al. (2001);
J	Bitran et al. (1986); Matsuo (1990); Kodama (1995); Chung et al. (2008);
K	Pfeifer (1989);Ward et al. (1991); Gerchak and Wang (1994); Feng and Gallego (1995);Lau (1997); Khouja and Robbins (2003);

Note: A: Extensions to different objectives and utility functions; B: Extensions to different supplier pricing policies; C: Extensions to different news-vendor pricing policies; D: Extensions to random yields; E: Extensions to different states of information about demand; F: Extensions to constrained multi-products; G: Extensions to multi-product models with substitution; H: Extensions to multi-echelon systems; I: Extensions to multi-location models; J: Extensions to models with more than one period to prepare for the selling season; K: Other extensions including yield management, their applications to specific industries and so on;

2.1.2 Contract Design and Supply Chain Coordination

Coordination is an important assessment criterion when we measure the performance of a supply chain. Thus, coordination is a key issue in this thesis and will be given intensive discussion. The terms network coordination, channel coordination or supply chain coordination all refer to the same state: “A single decision maker optimizes the network with the union of information that the various decision makers have" (Anupindi and Bassok, 1999). The performance of a supply chain is thus always at risk when there are multiple decision makers in the network who may have different private information and incentives. For example, suboptimal supply chain performance may be resulted from the decision makers' reluctance to share private information about cost and demand (Corbett and Tang, 1999). Since the local optima need not be globally optimal for the whole supply chain, when each decision maker optimizes their own private objective functions, the problem of double marginalization occurs, which is first described by Spengler (1950) in the Economics literature.

Fortunately, we can resort to various contracts in order to coordinate the supply chain. In general, the goal is to design contracting schemes that induce coordination through appropriate provisions for information and incentives such that all the members make efforts or decisions motivated by the same target. This type of approach recurs in a broad range of settings. Cachon (2003) provides an intensive review on five basic supply chain contracts and some other variants which are frequently-used. Chen (2003) reviews supply chain contracts with information sharing between (among) decision-makers. Early overviews on supply chain coordination with contracts were given by Whang (1995), Cachon (1999), Lariviere (1999), and Tsay et al. (1999). Besides, similar approaches can be found in related fields of study such as the economics literature of vertical integration.

There are several common contracts, including wholesale-price contract, buy-back contract, revenue-sharing contract, quantity-flexibility contract, sales-rebate contract and quantity-discount contract. All these different contract types are shown to coordinate the supply chain with one supplier and one retailer and arbitrarily divide its profit except the wholesale-price contract. However, if a firm's discount rate is not too high, indicating the firm cares about future profit, Debo (1999) shows that supply chain coordination is possible with just a wholesale-price contract. Among all the contracts, wholesale-price contract is the simplest one. With this contract, a the supplier charges the retailer w per unit purchased: $T_w(q,w) = q$. More complete analysis of this contract in the context of the newsvendor problem refer to Lariviere and Porteus (2001). Bresnahan and Reiss (1985) study the wholesale-price contract with deterministic demand. The wholesale-price contract is generally not considered a coordinating contract since the supplier earns a nonpositive profit. Due to there are two margins and neither firm considers the entire supply chain's margin when making a decision, Spengler (1950) points out that the wholesale-price contract is destined to result in coordination failure for this serial supply chain. Though this contract is simple, more complex contracts are often designed based on it. Generally, more complex contracts often include a wholesale price plus some adjustment that typically depends on realized demand (the quantity-discount contract is an exception).

Under a buy-back contract, the buyer purchases Q units with a price w_b per unit at the beginning of the season and may return part or even all of them at the end of the season for a refund of $b < w_b$ per unit. Pasternack (1985) is the first scholar to show that buy-back contracts can coordinate the fixed-price newsvendor, while allowing for any split of total supply chain profit. It can also be shown that the buy-back contract coordinates a supply chain as long as some requirements are satisfied (also see Cachon, 2003). Moreover, Cachon and Lariviere (2005) demonstrate that buy backs are equivalent to revenue-sharing contracts if the retail price is fixed. Interestingly, the two contracts are no longer equivalent under the assumption of a price-setting newsvendor.

With a revenue-sharing contract, the supplier charges w_r per unit purchased, in addition, the retailer allocates a percentage of his revenue to the supplier. All revenue is assume to be shared between the firms, including the salvage revenue. Let ϕ be the fraction of supply chain revenue the retailer keeps, so $(1-\phi)$ is the fraction the supplier obtains. Revenue-sharing contracts have been used in the video cassette rental industry with much success. An analysis of these contracts in a more general setting refers to Cachon and Lariviere (2005).

With a quantity-flexibility contract the supplier charges w_q per unit purchased but then compensates the retailer for his losses on unsold units. Hence, the difference between the quantity-flexibility contract and the the buy-back contract is that the former fully protects the retailer on a portion of the retailer's order whereas the latter gives partial protection on the retailer's entire order. If the supplier did not compensate the retailer for the c_r cost per unit, the retailer would then receive only partial compensation on a limited number of units, which produces a new contract and it is called backup agreement. Those contracts are studied by Pasternack (1985) and Eppen and Iyer (1997).

Sales-rebate contracts are often used in the hardware, software, and auto industries. Under this contract, the supplier charges w_s per unit purchased but then gives the retailer an r rebate per unit sold above a threshold t. Some studies call it 'markdown allowance' (e.g., Krishnan et al. (2004)). It can coordinate the fixed-price newsvendor if properly designed, but it is hardly applicable to the price-setting newsvendor. In addition, it is conducive to raise the market share, which can be achieved by considering the retailer's effort. For example, both Taylor (2002) and

Krishnan et al. (2004) allow the retailer to exert effort to increase demand: in the former study, effort is chosen simultaneously with the order quantity, whereas the latter focuses on the case in which the retailer chooses an order quantity, a signal of demand is observed and then effort is exerted. Hence, if the demand signal is strong relative to the order quantity, then the retailer does not need to exert much effort.

Unlike above contracts, there are many ways to structure a quantity discount schedule (Moorthy, 1987). One example is an "all unit" quantity discount contract. In this case, the supplier charges the buyer $w_d(Q)$ per order, where $w_d(Q)$ is the per unit wholesale price that is a decreasing function of Q. For the fixed-price newsvendor, the quantity discount can achieve coordination and allow to allocate supply chain profit arbitrarily. Quantity discount contracts are similar to revenue-sharing contracts since the buyer's expected profit is proportional to the supply chain's expected profit in both contracts. Of course, these contract types are not equivalent (Cachon and Lariviere, 2005). Comprehensive literature reviews on quantity discounts can be found in Dolan (1987). Wilson (1997) provides a broad discussion of non-linear pricing, while Tomlin (2003) investigates both quantity discount and quantity premium contracts.

Other contract types include the two-part tariff, price-discount contracts and franchise contracts. Some of them are composed of two or even more other contracts. For example, a price-discount contract contains a wholesale price and a buy-back rate. However, both contract terms are conditional on the chosen retail price which achieves coordination (Bernstein and Federgruen, 2005). Cachon and Lariviere (2005) show that revenue sharing is equivalent to price-discount contracts in the price-setting newsvendor model. A franchise contract combines revenue sharing with a two-part tariff. That is, the supplier charges a fixed fee, a per-unit wholesale price, and a revenue share per transaction. See Lafontaine and Slade (2001) for a review on this stream of literature. In a two-part tariff, the price of a product or service consists of two parts, including a lump-sum fee and a per-unit charge. Thus, it is often used as a technique of price discrimination.

We know that most of these contracts can coordinate the supply chain as long as some conditions are satisfied. However, it is still unknown whether the wholesale price is still unable to and the other coordinating contracts is still able to coordinate the channel after incorporating behavioral factors, such as social preferences of fairness concern and reciprocity, into the supply chain. In fact, our study shows that the wholesale-price contract is possible to coordinate the supply chain in a reciprocal channel. In addition, the conditions for coordinating contracts become stricter (it means that the coordinating conditions are more difficult to be satisfied) or more flexible if they can coordinate the behavioral channel, which refers to the channel considering behavioral factors? Research results of Chapter 3 and Chapter 4 will provide answers to these important questions.

2.2 Social preference

The prosocial behavior preference is widespread, which violates the basic self-interest hypothesis of traditional economics, is an important discovery of behavioral economics and experimental economics in the past several decades. These behavior preferences can be reflected by the following anomalies found in several important games: the responder rejects an positive allocation in the ultimatum game (Güth et al., 1982); The dictator may choose not to pocket all the money but share it with the other player in the dictator game (Forsythe et al., 1994); The two players reward each other in the exchange gift game (Kirchsteiger et al., 1996); the cooperation behavior in the public goods game (Marwell and Ames, 1979). The results of the serial of game experiments provide systematically strong refutation to economic self-interested assumption, which prompts the emergence of the social preference theory as the times require. On the basis of rational hypothesis, the models of social preference try to incorporate people's emotional factors, such as fairness concerns and reciprocity, into utility functions to revise the conventional assumption of economic man and formulate new game models by using the basic analyzing tool - game theory to explain a serial of anomalies and paradox found in the behavioral experiments. The core of social preference is that people are not only concerned about their own material payoff, but also other parties' benefits. Social preference is an important part of their utility functions.

Specifically, social preference can be classified as three preferences, including altruistic preference, preference of reciprocity and inequality aversion preference (i.e., fairness preference). Altruistic preference means that one's utility is increasing with other people's benefits and it is unconditional. We are not going to analyze this preference since it is a pure altruism without expecting anything in return and thus can't reflect the interaction well between the two players in the context of Stackelberg game. Both the preferences of fairness and reciprocity, however, are conditional. Outcome-based inequality aversion preference believes that both advantage inequality and disadvantage inequality lead to the decision-maker's utility decrease, but disadvantage inequality leads to more losses in utility, so he/she would punish his/her opponent at the cost lowing his/her own benefit. Intention-based preference of reciprocity emphasizes the intentions underlying actions. According to Rabin (1993), people help (punish) those who are kind (unkind) to them even at the cost of sacrificing their own material welfare. The kindness should be evaluated by analyzing the underlying intentions behind actions.

According to Kohler (2003), the embryo concept of social preference can be traced back to the literature of over half century ago (Ardzrooni et al., 1934; Duesenberry, 1949; Leibenstein, 1950; Pollak, 1976). The famous economist Camerer (1997) put forward the concept of social preference first. Fehr and Schmidt (1999) and Bolton and Ockenfels (2000) integrate social preference with experimental economics to formulate theoretical models, which marks the gradual improvement of social preference theory. However, it is not easy to give a rigorous definition for "social preferences". For example, "social preferences" has at least three other appellations, they are "interdependent preferences", "other-regarding preferences" and "prosocial preferences". Even so, they express the similar meaning which contradicts the self-interested preference, that is, people are concerned about their own benefits as well as other people's, which can be reflected by the important utility term of preferences in the decision-makers' utility functions.

In short, there is ample experimental evidence suggesting that a considerable proportion of play in two-person trust games deviates from the prediction derived on the basis of standard non-cooperative game theory (Berg et al., 1995; McCabe et al., 1998). A significant percentage of anonymously paired subjects arrive at cooperative outcomes. There are two classes of models attempting to explain these results (as well as the observed behavior in a variety of experimental games). One approach focuses exclusively on properties of the outcomes in these games. For example, models that posit a certain proportion of the population is altruistic or spiteful (Levine, 1998) or have certain thresholds of inequity aversion (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000) all fall within the class of outcome-based models. A second approach emphasizes the role of intentions in achieving cooperative outcomes in personal exchange. The models of McCabe and Smith (2000), Dufwenberg and Kirchsteiger (2004), Falk and Fischbacher (2006), for example, fall within the class of intention-based accounts. Whereas the outcome-based approaches imply that intentions are superfluous, intention-based models rely essentially on players reading each other's motives (and not merely their actions). Therefore, in the following part, we will review the literature relating to these two approaches respectively.

2.2.1 Outcome-based Inequality Aversion Preference

Outcome-based models assume that the agents have preferences for exhibiting inequity aversion. These agents try their best to narrow the difference between the two payoffs (it applies to games with more than two players), even at the cost of sacrificing their own material payoff. An important characteristic of models of inequality aversion is that they focus exclusively on outcomes. Loewenstein et al. (1989), Bolton (1991), Fehr and Schmidt (1999) (namely $F\&S$ model) and Bolton and Ockenfels (2000) (namely ERC model) develop different kinds of inequality-aversion models. Inequality-aversion model emphasizes that people tend to pursue an equitable outcome. This kind of model assumes that people have the motivation to decrease the difference between his payoff and other's. He will help other people if he is a leader in payoff by sacrificing his own benefit while damage other people's interests even at the cost of lowing his own payoff if he is falling behind.

In fact, the two models are quite similar with each other. In $F\&S$ model, given the social allocation $X \equiv \{x_1, x_2, ..., x_n\}$, the utility function of player i is $U_i(x) = x_i - \frac{\alpha_i}{n-1}\sum\limits_{j\neq i}\max\left\{x_j - x_i, 0\right\} - \frac{\beta_i}{n-1}\sum\limits_{j\neq i}\max\left\{x_i - x_j, 0\right\}, i \neq j$, where $\beta_i \leqslant \alpha_i$ and $0 \leqslant \beta < 1$. Specifically, in the two-person game, player i's utility becomes $U_i(x) = x_i - \alpha_i \max\left\{x_j - x_i, 0\right\} - \beta_i \max\left\{x_i - x_j, 0\right\}, i \neq j$. Both second terms of the above two utility functions measure the utility loss from disadvantageous inequality, while the third term measures the loss from advantageous inequality. Given his own monetary payoff x_i, player i's utility function obtains a maximum at $x_j = x_i$. The utility loss from disadvantageous inequality ($x_j > x_i$) is larger than the utility loss if player i is better off than player j ($x_j < x_i$). Blanco et al. (2011) assess the predictive power of $F\&S$ model by using a within-subjects design. They run four different experiments (ultimatum game, dictator game, sequential-move prisoners' dilemma and public-good game) with the same sample of subjects. Two parameters of inequality aversion were derived to test several hypotheses across games. They find that within-subject tests can differ markedly from aggregate-level analyzes. Inequality-aversion has predictive power at the aggregate level but performs less well at the individual level.

The difference between the inequality measures in ERC and $F\&S$ is represented in the motivation or utility function. The motivation function of ERC is given by $v_i(y_i, \delta_i)$, with y_i denoting the own payoff and δ_i the share of the total payoff, and v_i for given y_i being maximal if $\delta = 1/n$, n being the number of players. In ERC model, subjects like the average payoff to be as close as possible to their own payoff while $F\&S$ assumes that subjects dislike a payoff difference to any other individual. According to ERC, therefore a subject would be equally happy if all subjects received the same payoff or if some were rich and some were poor as long as she received the average payoff, while according to $F\&S$ she would clearly prefer that all subjects get the same. In a real life situation $F\&S$ predicts that the middle class would tax the upper class to subsidize the poor, while in an ERC world the middle class would be satisfied with the distribution (Engelmann and Strobel, 2004). ERC is an incomplete-information model and it can be applied to games played in the extensive as well as the normal form.

Though they are not complex, many stylized facts can be explained. The model is consistent with giving in dictator, trust, and gift-exchange games and with the rejection of low offers in ultimatum games. However, since the model does not account for intentions, the model fails to explain why people behave differently when playing against a random device instead of a real player, or why offers in a best-shot game are more readily accepted than in an ultimatum game.

The models of fairness concerns above can be used to capture situations in which agents' social preferences depend on payoffs of other economic agents, which can be termed distributional fairness concerns. However, people are also driven by social comparison (Festinger, 1954). That is, they not only have the preference for distributional fairness, but also have the motivation to look to their peers (people who are in similar circumstances) to evaluate their outcomes and judge whether they have been treated fairly, which is called peer-induced fairness concerns (Ho and Su, 2009). In their paper, peer-induced fairness in a social situation involving one leader and two followers is considered. The two followers are peers and peer-induced fairness concerns apply to both of them. There is distributional fairness between the leader and the follower since their relationship involves allocation of profit. The followers have a similar endowment and the leader plays an ultimatum game with each follower in sequence. They estimate that peer-induced fairness between the followers is two times stronger than distributional fairness between the leader and the follower by using laboratory experimental data.

2.2.2 Intention-based Reciprocity Preference

Another class of models (e.g. Rabin, 1993; Falk and Fischbacher, 2006; Dufwenberg and Kirchsteiger, 2004) also assigns fairness intention a major behavioral role (i.e., outcome is not the only criterion to measure fairness) when a decision-maker is going to make response to an action taken by another player. In short, substantial evidence reveals that inequality aversion cannot fully explain behavior, and that intention as well as expectations about others' behavior, also matter. For example, people is tending to respond more negatively to an unequal outcome resulted from an intentional choice than to an unequal outcome brought by nature. Individuals seem to have the trend to positively reciprocate kind intentions, and to display negative reciprocity as a response to hostile intentions. This is true even when the reciprocal acts yield no future or current monetary payoffs and might even be costly (Fehr and Gächter, 2000). Those models in which both consequence and intention are considered are called Reciprocity models. Reciprocity means that one responds to perceived kindness with kindness (i.e., positive reciprocity) and to perceived spite with spite (i.e., negative reciprocity). Therefore, "kindness" is a very important concept in the theory of reciprocity.

In many cases, an action with a good intention causes a bad consequence for other people, but other people can understand this and thus won't punish this action; on the contrary, people may retaliate an action which brings a good result to him because he believes that the intention of that action is malicious. The decision-maker has to guess the intention behind an action since he is not very sure whether it is good or not to him. Actions with identical outcomes may elicit different reciprocating responses depending how they are interpreted. In fact, this concept "kindness" has appeared in many papers and they may have different explanations. Rabin (1993) explicitly defines kindness in terms of the best and the worst material outcomes that could result from another player's strategy. Specifically, the perception of the kindness of an action is judged relative to a reference point. It is neutral if it allocates to a partner a payoff mid-way between the highest and lowest payoff the agent could allocate them. If it allocates more (less) than this, it is judged to kind (unkind). Dufwenberg and Kirchsteiger (2004) define the kindness of an action in relation to its effects on the range of feasible material outcomes. However, still some other scholars believe that the kindness of an action depends on both intention and the outcome of an action, where the latter is defined as the difference in the payoffs of receiving and sending subjects. According to Falk and Fischbacher (2006), people evaluate the kindness of an action not only by its consequences but also by its underlying intention. Stanca (2010) believes that at the empirical level, both intentionality, intended as free-will, and the set of alternative possibilities may contribute to define the perceived kindness of an action since comparison between the action intentionally chosen and the alternative actions that could have been chosen. In his opinion, what determines the perceived kindness of an action remains an open question.

The model of reciprocity can explain games such as ultimatum game (Blount, 1995), investment game (Cox, 2001), and mini-ultimatum game (Falk et al., 2003) while outcome-based models cannot. Cox and Deck (2005) find that negative reciprocity is not significant in the punishment mini-ultimatum game and that positive reciprocity is significant in the trust mini-investment game with a single-blind protocol but insignificant with a double-blind protocol. Fehr and Gächter (2000) show that reciprocity has powerful implications for many economic domains. It will enhance the possibilities of collective action since it is an important determinant in the enforcement of contracts and social norms. At the same time, however, reciprocity may lead to inefficiency of the provision of explicit incentive because the incentives may crowd out voluntary co-operation.

Sutter (2007) examines whether and how the relative importance of outcomes or intentions for economic decisions develops with age. He conducts this experiment under the ultimatum games with children, teens and university students and finds that children and teens react systematically to perceived intentions, like university students do. However, children and teens reject unequal offers much more often than university students, indicating that outcomes are relatively more important than intentions for younger subjects. Hence, he concludes that the relative importance of intentions increases with age.

The concept of reciprocity captures a motivational force behind human behavior. Reciprocity can be distinguished from simple altruism, which corresponds to unconditional generosity. A crucial feature of the psychology of reciprocity is obviously that people decide about their actions towards others not only according to the material consequences resulting from the actions taken by the latter, but also depend on the intentions attributed to them. Positive(negative) reciprocity is the impulse or the desire to be kind(unkind) to those who have been kind(unkind) to us. This reciprocation to kindness or unkindness can occur even at the cost of losing material benefits of the responders.

Gift exchange game is an example of positive reciprocity. It was conducted by Fehr et al. (1993) first. Offerman (2002) and Falk et al. (2003) repeated this game for several times. In this game, the proposer (represents a frim) provides a fixed wage $w \in (\underline{w}, \overline{w})$. If the responder (represents an employee) declines, both of them get nothing. The responder has to determine e if he accepts it, where $e \in (\underline{e}, \overline{e})$ is the effort he makes. The proposer's profit is $u_p = ve - w$, where v is marginal production rate for the effort; the responder's revenue equals $u_s = w - c(e)$, where

$c(e)$ is a concave function and denotes the cost for effort. According to the selfish preference, the responder makes the lowest effort for any fixed wage $w \in (\underline{w}, \overline{w})$, the proposer provides the lowest wage $\underline{w}$, and there is no relationship between the wage and the effort. However, the results of the experiment show that the wage provided by the proposer is higher than $\underline{w}$ and the responder makes an effort which is greater than $\underline{w}$. This conclusion is very different from the prediction of traditional theory.

The ultimatum game belongs to negative reciprocity. It has been investigated intensively. Overviews of experimental results are given by, e.g., Güth et al. (1982), Thaler (1988), Güth (1995), Camerer and Thaler (1995), and Roth and Erev (1995). In the ultimatum game, the first mover ("proposer") receives an amount of money (which can be normalized to 1). He has to make an offer c to the second mover ("responder"), where $0 \leqslant c \leqslant 1$. The responder either accepts or rejects the offer. If she accepts, the resulting payoffs are $1-c$ for the proposer and c for the responder. Payoffs are zero for both parties in the case of rejection. The outcome according to the subgame perfect Nash equilibrium is ($c = 0$;accept) under the standard assumptions. However, the reported behavioral regularities are quite different and they can be summarized as follows: (1) pratically no offers exceed 0.5; (2) offers below 0.2 are extremely rare; (3) the modal offers lie in a range between 0.4 and 0.5; (4) offers close to 0.5 are pratically never rejected, the rejection rate for offers below 0.2 is very high. The dictator game is similar to the ultimatum game, but the second player has no choice and must accept the first player's offer. Experiments show that proposers in dictator games usually offer less than in the ultimatum games. About 80 percent of subjects offer a positive amount while practically nobody offers more than 50 percent.

Blount (1995) points out the influence of intentions on the decision for the first time. For example, a responder is facing an allocation (8,2) proposed by a proposer in the ultimatum game (he gets 2), the rate of rejection is very high. However, if this allocation is produced by random selection instead of other players, the responder is more likely to accept it. The reason is that the allocation proposed by other players indicates their intentions behind it while the one produce by random selection doesn't. Enlightened by this idea, Nelson (2002) demonstrate this explanation by using a standard ultimatum game and a truncated ultimatum game. The study of Falk et al. (2003) has a similar experimental design. The two studies are different in design, but in essence, both of them are going to use two allocations to reflect the proposer's intentions and investigate whether the intentions have impact on the responder's behavioral decisions or not.

Their results are consistent, that is, people's behavioral decisions are affected by other people's intentions.

Prominent formalizations of reciprocity based on intentions have been given by Rabin (1993), Charness and Rabin (2002), Dufwenberg and Kirchsteiger (2004) and Falk and Fischbacher (2006). Rabin (1993) is the first scholar who adopted the framework of psychological games of Geanakoplos et al. (1989) to suit the phenomenon of reciprocity and define the fairness equilibrium. He introduced so-called fairness games in which a reciprocity payoff is added to the material payoff of the players. The reciprocity payoff is calculated as the product of a kindness term and reciprocation term. The kindness term is positive when a player feels treated well. Then he or she tries to make the reciprocation term positive in order to increase his or her total utility payoff. This is achieved by being nice in return. Negative reciprocity is modeled analogously.

Before describing the kindness or unkindness of an intention, Rabin defines a kindness function $f_i(a_i,b_i) \equiv \frac{x_j(b_j,a_i)-x_j^f(b_j)}{x_j^h(b_j)-x_j^l(b_j)}$ in order to show the kindness or unkindness of an action's intention, where a_i is i's action, b_j is i's conjecture about what action j takes, $x_j(b_j,a_i)$ denotes the payoff of j when j takes b_j and i adopts a_i, $x_j^h(b_j)$, $x_j^l(b_j)$ and $x_j^f(b_j)$ represent j's maximum, minimum and "equitable" payoffs if he takes b_j. $f_i > 0$ means that the intention behind an action taken by i is good (kind) while $f_i < 0$ means unkind (bad) intention, $f_i = 0$ represents neutral and thus cannot reflect the underlying intention. $f_i'(b_j,c_i)$ is used to denote the player i's belief about how kind player j is being to him, where $f_j'(b_j,c_i) \equiv \frac{x_i(c_i,b_j)-x_i^f(c_i)}{x_i^h(c_i)-x_i^l(c_i)}$, where c_i represents i's conjecture about i's guess about what action i adopts. $f_j' > 0$, $f_j' < 0$ and $f_j' = 0$ indicate that i believes that j's intention is good, bad and neutral, respectively. Based on this, i's utility function is $u_i(a_i,b_j,c_i) \equiv x_i(a_i,b_j) + f_j'(b_j,c_i)\left[1+f_i(a_i,b_j)\right]$, where the first term of the equal sign's right side is the utility produced directly from material payoff and the second term is the utility resulted from reciprocity. Another important assumption is "rational expectations", i.e., $(a_i,a_j) = (b_i,b_j) = (c_i,c_j)$ at equilibrium.

Rabin contributes a lot in building a reciprocity model based on underlying intentions. However, this model is restricted to simultaneous, two-player normal-form games. This implies a drawback when a sequential game is rewritten in normal form and solved accordingly: Rabin's model can not take the sequential structure of the game into account. Therefore, an equilibrium in Rabin's model may allow for non-optimizing behavior at information sets that are not reached. The paper of Dufwenberg and Kirchsteiger (2004) is closely related to Rabin's.

They generalize Rabin's model to n-person extensive-form games of imperfect information. In contrast to Rabin, they impose not only subgame perfection but also sequential rationality in non-proper subgames. The main idea behind their extension is to keep track of players' beliefs about the strategy profile being played as the game evolves. Falk and Fischbacher (2006) also extend Rabin's approach, but to extensive-form games of perfect information. They use a more complex utility function that allows for equity concerns and intentions.

Models that take into account players' fairness intentions and distributional preferences are consistent with the data of Falk et al. (2003) while models that focus exclusively on intentions or the distribution of material payoffs are not. Their model shows that identical offers in an ultimatum game generate systematically different rejection rates depending on the other offers that are available to the proposer. This result casts doubt on the consequentialist practice in economics to define the utility of an action solely in terms of the consequences of the action irrespective of the set of alternatives. It means, in particular, that negatively reciprocal behavior cannot be fully captured by equity models that are exclusively based on preferences over the distribution of material payoffs. In Falk and Fischbacher (2006), comparison between two ultimatum games was given to demonstrate the importance of intention. There are two so-called reduced ultimatum games, game (a) and game (b) respectively (which shows in Figure 2.2 [1]). In game (a), the first mover (i.e., the proposer) has a chance to divide 10 dollars between himself and the second mover (i.e., the responder). He has only two choices, either offering 2 dollars to the responder and keeping 8 dollars or offering an equal split. The responder can either accept or reject the offer. Both of them get nothing if the responder rejects the proposer's way of split. In the game (b), the two possible offers he can choose from are the 8/2-offer, just as the game (a) and a 10/0-offer which means the responder get nothing. In the second game (i.e., game (b)) of their example, it suggests that the responder will forgive the proposer and thus may not choose internecine result to punish him if the proposer selects branch **Z**. The detailed experimental process and results refer to Falk et al. (2003). This experiment clearly suggests that, in addition to the distributive consequences of the action, it is necessary to take into account the intention signaled by the action as well. This interpretation is also supported by the experiments of Blount (1995), Brandts and Solà (2001), and Güth et al. (1998). It seems that this example will negate our previous viewpoint that the consequence can not be neglected. However, we have following explanation to this doubt. Firstly, they didn't say that the responder

[1] The picture derives from Falk and Fischbacher (2006).

will definitely accept what the proposer offer, said differently, it's possible for the responder to make the choice of getting nothing for both. Furthermore, in the context of supply chain, the strategy spaces of two members are continued and thus are not different from that of the ultimatum game. The decision-maker [2]is not so easy to decide whether the opponent is kind to him or not since the boundary is not very clear. That is what we want to expound in detail in the following parts.

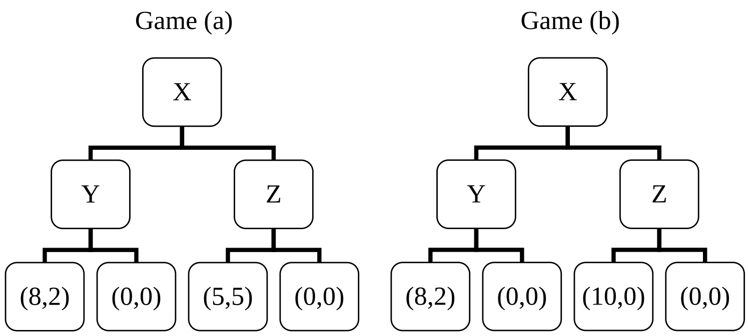

Figure 2.2: Two games that show the importance of intentions

After comparing many extant reciprocity models, Korth (2009) conclude that the model built by Falk and Fischbacher (2006) is most successful in predicting behavior observed in experiments with computable unique equilibria for many games. Moreover, using two free parameters ρ and ε for each player's utility function, it is furthermore possible to overcome former models' shortcomings and thus can model and explain many phenomena, such as pure self-interested behavior, pure inequity aversion, or pure intentional reciprocity. The model of Chapter 4 is developed based upon the work of Falk and Fischbacher (2006) because it is a very powerful tool for predicting behavior resulting from a variety of preferences in many different games.

2.2.3 Status Seeking Preference

Generally speaking, People feel happy if they are getting rich and prefer a rich life rather than a poor one. An individual's utility is usually stated in terms of the absolute levels of economic variables, such as consumption of wealth, goods and services, leisure, etc. There is evidence, some of which is provided by (Easterlin, 1974, 1995), Clark and Oswald (1996), Oswald (1997),

[2]In the model, "decision-maker" could be the supplier or the retailer, the opponent or the partner refers to the other member.

and Frank (1997), to show that an individual's economic well-being depends largely on his relative position, or status, in society. Richness is a relative concept instead of absolute one. That is, measures of richness are based on subjective judgments. "Keeping up with the Joneses" is popular in daily life. For example, we are dying to know the ranking of GPA (grade point average) after examination and inquire colleague's wages. Social status has long been recognized as a powerful motivating force in society. Adam Smith believes that the human desire for the respect and admiration of others is at times more influential on behavior than the satisfaction derived directly from the consumption of market goods and services. The phrase "conspicuous consumption" is used by Cummings (1899) to describe how consumption decisions were often motivated by the "demonstration effects" of goods that made one's wealth visible to others.

The tendency to desire higher relative positions, or higher social status, is called status seeking preference. Some Sociologists define status as people's relative standing in a group and this standing is based on wealth, prestige or honor (Berger et al., 1972; Thye, 2000). Others argue that status refers to a kind of rank ordered relationship among players which is formed from actors' implicit evaluations of themselves and each other according to some shared standard of value (Ridgeway and Walker (1995), p. 281; Loch et al. (2000)). Evidence of the importance of relative income in determining well-being can be found in the "Easterlin paradox", a reference to numerous subjective surveys finding that higher relative income contributes to self-reported "happiness", but the parts of rising incomes for society overall seem not making people, on average, happier (Easterlin, 1973).

Some studies argue that individuals pursue status because it gives them access to greater economic and social resources, and they use economic and social resources to improve their status. For example, studies show that improving one's rank in the social hierarchy has direct impact on social influence, which in turn puts an individual in a better position to pursue activities that are more directly lucrative (Ridgeway and Walker, 1995). Studies by Ball and Eckel (1996) and Ball et al. (2001) suggest that individuals with higher status tend to obtain better terms in negotiations than individuals with lower status. Similarly, studies by Ensel (1979) and Marsden and Hurlbert (1988) have shown that during job transition status plays a crucial role in obtaining more highly regarded and better paying jobs. Other studies argue that status seeking is often pursued as an "ego reward": a valuable emotional good that individuals accumulate as a result of acquired status (Emerson, 1962). The source of status as an emotional good tends to vary. It may be rooted in the psychological need of individuals to generate better sentiments among peers (e.g., admiration), it may be due to socialization that equates status with living up to a certain normative ideal, or it may be simply that status generates more gratifying social contact (Homan, 1950).

There is an argument whether people chase status emotionally or rationally. Substantial evidence in evolutionary anthropology (Barlow, 1989; Chapais, 1991; de Waal, 1996) and some agreement in sociology (Kemper and Collins, 1990), indicates that status seeking is emotionally-driven and (the pleasure of status) can operate as an end in itself. Emotionally-driven status preference has its roots in a general primate tendency toward social hierarchy, where evolution favors competition for food, mates and nesting sites among group members to be performed efficiently with as little injury as possible. Without actually fighting, determining who wins an encounter between two competing individuals, leads to a status hierarchy in primate groups. Human prestige has developed from this primate status tendency and has become symbolic. Symbolic prestige is culturally determined to a large extent and can rest on various criteria, such as knowledge and skills, or the control of resources (Barlow, 1989). People are eager to be generally respected and recognized in all cultures of the world. For example, in order to have abundant meat so that they can raise their status by sharing and "showing off" in front of other clansmen, men of the Ache tribe of Paraguay are willing to pursue risky hunting strategies (Buss, 2004).

Jaeger (2004) concludes that there are two ways to formulate the preference for status concerns in extant literature. The first one takes an instrumental approach with which the decision-maker's utility function do not involve status concerns directly. Instead, preferences appears only as a function of an agent's consumption. This approach can be used to model reduced-form preferences for social status. The second one includes status in individuals' direct preferences (e.g., Bagwell and Bernheim, 1996; Bisin and Verdier, 1998). The basis of such status preferences arises from a long-term evolutionary process (Fershtman and Weiss, 1997, 1998). Alternative forms of the evolutionary model are proposed, including ones in which the players crave to ascend a social hierarchy may have selection value (Postlewaite, 1998). In a model where evolutionary fitness depends only on economic outcome while involves interactions among players through randomly matched games, Fershtman and Weiss (1997) shows that an evolutionarily stable state under which all individuals are concerned about social standing may appear when some requirements are satisfied.

Huberman et al. (2004) experimentally show that subjects are willing to trade real money for short-lived status recognition that has no further benefits. Research has also found that this pleasure corresponds to higher serotonin levels, which are both a cause and an effect of higher status, as demonstrated in studies of the relationship between serotonin levels and social success within college fraternities (Booth et al., 1989). Economists have observed the systematic effect of status striving, and have modeled it. For example, Frank (1984, 1985), the pioneer of status research, showed that striving for status can be productive for an organization if it rests on criteria that are connected to productivity. Although far from providing conclusive answers, a large and growing body of work, referred to in economics as the happiness literature, suggests that relative position affects well-being. For example, Frank (1999) argues that different measures of happiness and well-being are often found to correlate positionally with economic variables. These measures range from self-reported happiness questions in surveys to electromagnetic activity levels at different sites in the brain. By extension, status seeking consists of activities designed to improve an actor's standing in a group, and is therefore judged by the degree to which associated activities result in increasing prestige, honor, or deference. The aim of status seeking can be external and internal. Actors may seek status for pure economic and social advantage, but they may also seek status for psychological and emotional reasons. Although the two drivers are not mutually exclusive, their preponderance depends on the nature of the group involved (Perretti and Negro, 2006). In general, there are two alternative ways in which status is modelled in macroeconomic settings. Some researchers (Persson, 1995; Harbaugh, 1996; Rauscher, 997b; Grossmann, 1998; Ljungqvist and Uhlig, 2000; Fisher and Hof, 2000) model status based on the argument that status derives from relative consumption. In contrast, (Corneo and Jeanne, 1997, 001a,b), Rauscher (997a), Futagami and Shibata (1998), Fisher (2004), and Hof and Wirl (2003) consider that status arises from relative wealth.

Konrad and Lommerud (1993) introduce relative standing comparisons, or "status seeking" into their utility functions from the perspective of social level. de Bruyn and Bolton (2008) improve the asymmetric loss function and investigate the influence of fairness considerations on bargaining. The results show that their model, in which the decision-makers are assumed to be fairness concerned and have bounded rationality, is in line with the empirical or experimental data. They conclude that out-of-sample forecasts offer better predictions than traditional preference models that ignore fairness considerations. Extant literatures have insufficiently take into consideration the choice of fairness reference of supply chain members. In the experiment of Loch and Wu (2008), first- and second-mover price decisions are correlated in the status condition, because player B responds with a price that is more aggressive than in the control condition if player A sets an aggressive price, which means he/she gives up substantial profits to deny player A status (being the winner), though the status symbol is private, fleeting, and has no material payoff or future value.

It is worth noting that the preference for status seeking is used as an important part to describe fairness concerns in Chapter 3 and it is not discussed and analyzed as an independent preference in this thesis. It thus plays an significant role in formulating the model of fairness concerns.

2.3 Relevant Literature of Game Theory

Game theory has become an essential tool to analyze the supply chains with two or multiple agents, often with conflicting objectives. In this thesis, there are at least three concepts which are related to my study. They are "Stackelberg Game", "Nash Bargaining Game" and "Psychological Game". More detailed contents about how to apply game theory to the supply chain analysis, please refer to Cachon and Netessine (2004). In fact, "Psychological Game" doesn't belong to the classical game theory since its analysis involves Psychological factors, such as emotions, intentions and so on. Therefore, I would like to give a short review about above three important concepts as follows.

2.3.1 Stackelberg Game

Stackelberg Game is one of the most important games in game theory. Basic Stackelberg Game involves two players, one player acts as a leader and the rest as a follower (complex Stackelberg Game may involve several leaders or several followers). The problem is then to find an optimal strategy for the leader, assuming that the followers make a response in such a rational way that they optimize their objective functions given the leader's actions. This is the static bi-level optimization model introduced by German economist Von Stackelberg (1952). A so-called method of "backward induction" is employed to solve this game and the first and most important step is to find the best response function. Best responses are typically defined implicitly through the first-order conditions and thus makes the analysis difficult, but we can still gain some important managerial insights by finding out how each player reacts to an increase in the stocking quantity by the other player. Stackelberg game is used in this thesis to model the strategic interactions and sequential decision making between the supplier and the retailer.

Within the context of a perfect information, Stackelberg equilibrium can be interpreted as a Subgame Perfect Equilibrium (Reinhard, 1965) in extensive form where the leader moves first. It would be clear if the best response for the follower is unique. However, some problems may arise if the best reply of the follower is more than one since the leader can't predict the follower's choice simply based on his rational behavior. Thus, from the leader's point of view, the best strategy may be quite problematic. There are two most common approaches introduced and called generalized Stackelberg strategies (Leitmann, 1978) to solve this problem. The first one is to assume the leader has a "pessimistic" attitude, which leads to the so-called weak Stackelberg problem; the second one is opposite, i.e., assume an "optimistic" one, which produces the strong Stackelberg problem (see also Basar and Olsder, 1982; Breton et al., 1988). In both approaches, the follower is assumed to choose the worst (best) action for the leader, in case of indifference.

Another difficulty lies in the fact that the existence of a solution to the weak Stackelberg problem cannot be guaranteed (Basar and Olsder, 1982), and the strong Stackelberg case does not display continuous dependence on the data of the problem even if existence holds. These issues have been considered and the difficulties partially overcome by using approximate solutions, please see Lignola and Morgan (1995, 1997) and Loridan and Morgan (1989). This approach, which can be considered as very natural from a numerical viewpoint, however, does not solve the uniqueness problem for the best response. Thus, difficulties remain from the point of view of the numerical solution of the problem. To overcome the numerical difficulties, due to the non-uniqueness of the best response, regularization methods have been provided to tackle this problem like Tikhonov regularization (Loridan and Morgan, 1992) and the approaches followed by Dempe and Schmidt (1996) to solve the strong Stackelberg problem and by Molodtsov (1976), Sholokho (1970) and (Loridan and Morgan, 1992, 1996).

In Chapter 4 of this thesis, we are confronted the similar problems in calculating the equilibria even under a simple context of Stackelberg game. Firstly, the uniqueness of best response can't be guaranteed due to several scenarios may appear. In addition, the existence of the equilibria is hard to demonstrate due to the fact that the reciprocity model is so complicated. Fortunately, we can solve these problem dexterously at last.

After the Stackelberg game is proposed, many scholars contribute to its developments and extensions, including static and dynamic nonzero-sum two-player games (e.g., Simaan and Cruz Jr, 1973), multistage and deterministic Stackelberg games (e.g., Luh et al., 1984), open-loop Stackelberg games (e.g., Abou-Kandil and Bertrand, 1985), closed-loop Stackelberg games (e.g., Kicsiny et al., 2014), incomplete information Stackelberg games (e.g., Normann, 1997) and their combination (e.g. Nie, 2005).

Stackelberg games are widely used within the context of supply chain. Therefore, it is not difficult to find relevant literature, whereas we just give a brief review. It can be simply classified into the simple structure (i.e., a single supplier and a single retailer) and the complex structure (more than two players) Stackelberg games. Though the structure of One-single supplier and one-single retailer is simple, it is often used in the context of supply chain because it is more tractable and can provide us with enough important problems to study. For example, Monahan (1984) analyzes a supply chain consists of one-single vendor and one-single buyer with constant demand and price discounts based on an order quantity. A Stackelberg game is used to for the vendor to design an optimal discount scheme in order to increase its profit. The inventory problem is analyzed on the buyer side with an EOQ-type cost structure. Hsiao and Lin (2005) discuss a buyer-vendor EOQ model with changeable lead-time within the context of Stackelberg game. Cui et al. (2007) study a dyadic channel in which one manufacturer and one retailer plays Stackelberg game by considering fairness concerns. Within the context of simple Stackelberg game, Loch and Wu (2008) experimentally investigate the impacts of social preferences, such as relationships and status seeking, on the decisions of the supply chain. A survey regarding recent applications of Stackelberg differential game involving two players labeled as 1 (the leader) and 2 (the follower) making decisions over a finite horizon T within the context of the supply chain, please refer to He et al. (2007).

There are also a lot of relevant literature in complex structure Stackelberg games. Stackelberg game is employed by Several papers (e.g., Rosenblatt and Lee, 1985; Weng, 1995; Munson and Rosenblatt, 2001; Wang, 2002) to address the replenishment problems in which the vendor adopts simple lot-for-lot policies. To overcome the problem that the supplier is not satisfied with the lot-for-lot policy, Stackelberg game is used by Wang (2001) to develop supplier's optimal quantity discount policy when the replenishments of the supplier and buyers are coordinated with using a power-of-two policy. However, Wang (2004) later finds that a power-of-two inventory policy is not always able to guarantee the existence of a stable equilibrium coordination mechanism but an integer-ratio policy always can when buyers act opportunistically and independently. An integer-ratio policy, combined with Stackelberg games is more, or at least equally effective compared with a power-of-two policy. As such, under the structure of Stackelberg games, an integer-ratio time coordination scheme is recommended in order to coordinate a decentralized supply chain. Yu et al. (2009a) study Stackelberg games and its improvement in a VMI-type supply chain in which the vendor is a manufacturer. Yu et al. (2009b) investigate how a manufacturer and its retailers interact with each other in order to optimize their own net profits by adjusting product marketing (pricing and advertising) and inventory policies in an information-asymmetric VMI (vendor managed inventory) supply chain. In order to make their problems tractable, each member's inventory is managed by himself with relatively simple inventory policies in those models.

2.3.2 Nash Bargaining Game

In the model of Chapter 3, Nash bargaining solution (a two-tuples) is used as the fairness reference point for the supplier and the retailer. Therefore, Nash bargaining game is important and it is necessary to give an introduction, but a brief one due to the space limitations.

Nash bargaining game is originally used to describe a two-person bargaining situation, which involves a set S of possible agreements. $s \in S$ represents the physical outcomes for the two parties if $s = (s_1, s_2)$ is acceptable by both. On the basis of this simple framework, other relevant issues include the players' preferences toward risk, time and even fairness, and the bargaining sequence (who choose to offer and who choose to accept), etc. The original static axiomatic framework of bargaining game is proposed by Nash (1953) and a Nash bargaining problem can be represented by $B(S, d; u_1, u_2)$, where $d = (d_1, d_2)$ denotes the disagreement point, $u_1 = u_1(s) = u_1(s_1)$ denote the player 1's utility, $u_2 = u_2(s) = u_2(s_2)$ is the player 2's utility from accepting the agreement s. The disagreement point d_i represents the greatest payoff for the player i if he withdraws from the bargaining and obviously, the players would not accept the allocation plan which is lower than (s_1, s_2). As suggested by Roth (1985), the two-person bargaining solution can't be obtained solely based on the parties' ordinal preferences over S. Therefore, the solution to Nash's problem is the unique element in S which maximizes the Nash product $(s_1 - s_1^0)(s_2 - s_2^0)$ (or in the form of utility function $(u_1(s_1) - u_1(s_1^0))(u_2(s_2) - u_2(s_2^0))$) and simultaneously, satisfies four axioms: Pareto efficiency, symmetry, linear invariance and independence of irrelevant alternatives. Several papers (e.g., McDonald and Solow, 1981; Grout, 1984; Ellis and Fender, 1985) point out some problems of Nash's static axiomatic approach when it is applied to wage negotiations over income streams. These problems include the parties' attitudes toward risk are not immediately relevant, the ambiguities that may arise in locating the disagreement s^0 and so on. The researches of Rubinstein (1982), Crawford (1982) and Moulin (1984) make a contribution to overcoming these defects by developing dynamic strategic approach and considering the the possibility of failure of negotiation. Binmore (1980) observes the link between the equilibrium outcome in Rubinstein's model and the Nash solution. The asymmetry in the bargaining procedure or in the parties' beliefs is considered by some researchers, that is, the players make their decisions based on maximizing $(s_1 - s_1^0)^{\beta}(s_2 - s_2^0)^1 - \beta$, where β denotes the player 1's bargaining power and $1-\beta$ the other party's bargaining power. Based on the above studies, relationship between the static axiomatic theory of bargaining and the sequential approach to bargaining has been established and a guide for the application of the Nash bargaining solution to economic modelling is provided by Binmore et al. (1986).

It is not difficult to find literature in which Nash bargaining solution is applied. Huang and Li (2001) explore the role of vertical cooperative advertising efficiency with respect to transactions between a manufacturer and a retailer. Three cooperative advertising models are discussed, one of which is formulated as a Stackelberg structure. In Chapter 3 of this thesis, Nash bargaining game is employed to determine the best sharing rule. The difference between the two models is that in their paper, the two members play a Stackelberg-like game first to make a "pie" and then bargain how to distribute this "pie" by Nash bargaining model, while in our paper, the two members form fairness reference in their own mind first, which are based on Nash bargaining model, and then play a Stackelberg-like game on the basis of this fairness reference. Nash bargaining model really happens in the second stage in their paper while it virtually happens in minds in the first stage in our paper. Wu et al. (2009a) and Dash Wu (2011) also consider these two different games simultaneously. In addition, the Nash bargaining solution (NBS) can be used in computer science. For example, NBS is applied to solve the problem of bandwidth allocation by Touati et al. (2006). They show that they are indeed more suitable for applications that have concave utility. Based on the concepts of Nash bargaining and dual decomposition, Shrimali et al. (2010) propose a novel approach to inter-domain traffic engineering. Moreover, by retaining the empirically appealing feature of Nash bargaining and modify the conventional model of unemployment dynamics proposed by Mortensen and Pissarides (1994) to allow for staggered multi-period wage contracting, Gertler and Trigari (2006) take a pragmatic approach to modelling wage rigidity and developing a framework that is tractable for quantitative analysis. Grout (1984) employs a generalized Nash bargain to analyze input levels, profits and wages without legally binding contracts, and compares the results with the conventional contracts model.

2.3.3 Psychological Game

Psychological games is quite different from the conventional games in that a player's payoff depends not only on what strategy profile is played, but possibly also on what is the player's beliefs about other players' strategic choices or beliefs. It may be difficult to understand these games since they involve beliefs and conjectures. Therefore, It is necessary to introduce some knowledge of psychological game and review relevant literature about it.

An important article about psychological game is accomplished by Gilboa and Schmeidler (1988). They study a so-called information-dependent game in which a player's utility depends upon his prior knowledge that the outcome will lie in a particular subset of outcome space. These sets parametrize utilities just as the players' belief hierarchies do in a psychological game. Some examples are given to illustrate how emotions (including the effects of revenge, surprise, and fashion-consciousness) can be modeled in their framework.

Emotional reactions often depend on expectations. An event might result in some feelings caused by gratitude, disappointment, anger, or embarrassment depending on what the individual expected ex ante, or thought others expected, and so on. According to Geanakoplos et al. (1989) (hereafter GPS), which is a seminal article of psychological game, "the payoffs to each players depends not only on what every player does but also on what he thinks every player believes, and on what he thinks they believe others believe, and so on". They demonstrate that subgame perfect and sequential equilibria always exist in psychological games, though back induction can not be applied and the existence of the "perfect" psychological equilibria can't be guaranteed. Psychological games and psychological equilibria can be used to model belief-dependent emotions such as surprise and anger while conventional game theory can't. Moreover, there is an important assumption in these games, that is, beliefs are assumed to correspond to reality in equilibrium.

Gilboa and Schmeidler (1988) and Geanakoplos et al. (1989) are two important papers of psychological game and are different at least in the following two aspects: (1) the former aims to illuminate certain paradoxes of common knowledge, whereas the latter is interested in exploring the logic of sequential rationality in psychological games and proving the existence of solutions for game whose payoffs depend on belief hierarchies; (2) the solutions of the latter are similar to traditional equilibrium notions while the former doesn't. Nalebuff and Shubik (1988) also study emotional factors in strategic analysis but is less closely related.

Backward induction's failure in psychological games is due to the fact that when a node is reached, it does not capture adequately the state of the game: the node identifies a history of play, but it doesn't include the player's beliefs. This result implies that the usual proof of the existence of a subgame perfect equilibrium cannot be applied to psychological games. However, these games always have equilibria, which are similar to subgame perfect equilibria and sequential equilibria, respectively. Thus, there is no conflict between the usual notions of sequential rationality and the presence of psychological influences on players' behavior.

Rabin (1993) adopts the framework of GPS to incorporate fairness into game theory and economics. He derives psychological games from basic "material games". In his work, assumptions about fairness is used to derive psychological games from the more traditional material description of a situation, whereas GPS put forward a technique for analyzing games with emotions. Therefore, he believes that his model can be applied generally and can be compared directly to conventional economic analysis. Additionally, a standard battle-of-the-sexes game is used as an example to motivate the general framework and his specific model. In this game, player 1 gets payoff $2X$ and player 2 gets payoff X if they go to watch opera together; when they go to play boxing together, the payoffs for player 1 and player 2 are X and $2X$, respectively. Both of them get zero if they don't do the same thing together.

Of course, (boxing, boxing) is a traditional Nash equilibrium in this game. In order to see the importance of beliefs, suppose player 1 believes (a) that player 2 will play boxing, and (b) that player 2 believes that player 1 is watching opera. Now player 1 concludes that player 2 is reducing her own payoff in order to harm him. Player 1 feels hostility toward player 2 and thus wish to hurt her. Player 1 may sacrifice his own material well-being and play opera rather than boxing if this hostility is strong enough. Indeed, if both players have strong enough emotional reaction to each other's behavior, (opera, boxing) will be an equilibrium. In the induced atmosphere of hostility, both players will hope to stick with it if it is common knowledge that they are playing this outcome.

Notice the main role of expectations is that player 1's payoffs not only on the actions taken, but also on his beliefs about player 2's motives. Unfortunately, it seems impossible to model these emotions directly by transforming the payoffs in the conventional way. In the natural sense, both equilibria discussed above are strict, which means that each player strictly prefers to play his own strategy when the equilibrium is given. In the equilibrium (boxing, boxing), player 1 strictly prefers playing boxing to watching opera. In the equilibrium (opera, boxing) player 1 strictly prefers opera to boxing. No matter what payoffs are chosen, these statements would be contradictory if payoffs depended solely on the actions taken. Therefore, it is necessary to develop a model that explicitly incorporates beliefs in order to formalize these preferences. Kolpin (1992) argues that one can apply conventional game theory to these psychological games by considering the choice of beliefs as additional parts of players' strategies. However, Rabin's point here is that the results he obtains could not be derived simply by respecifying the payoffs over the physical actions in the game.

Dufwenberg and Kirchsteiger (2004) develop a theory of reciprocity for extensive games in which the sequential structure of a strategic situation is designed explicitly. They believe that the psychological games they consider do not belong to the class of psychological games that receives the most attention in GPS, which confines attention to psychological games where only initial beliefs have a direct bearing on players' payoff perception (although they suggest that other assumptions may be important). In the model of Falk and Fischbacher (2006), beliefs about actions, which do not belong to the current subgame, are irrelevant for determining these utility components. By defining utility components in each node, this model can solve updating in the outcome and the reciprocation term.

2.4 Apply Behavioral Factors to Specific OM Settings

Another stream of literature closely related to our paper is the examination of influences on the decisions after incorporating some behavioral factors, especially social preferences into the context of OM setting, particularly the context of supply chain.

Cui et al. (2007) incorporate fairness concerns into the conventional dyadic channel to investigate how fairness may affect the decisions of the manufacturer and the retailer. The results show that the manufacturer can use a simple wholesale price above her marginal cost to coordinate this channel both in terms of achieving the maximum channel profit and in terms of obtaining the maximum channel utility if both two members are concerned about fairness. Therefore, channel coordination in a channel where partners care about fairness does not require any nonlinear pricing scheme such as a two-part tariff and quantity discount. In addition, the problem of double marginalization need not always be present in a channel because of the retailer's concerns with fairness. Katok (2011) extends the model to include incomplete information. Based on the model of Ho and Su (2009), Ho et al. (2013) extend the model of Cui et al. (2007) to a setting with one supplier and two retailers and consider both peer-induced fairness concern and distributional fairness concern simultaneously. Caliskan-Demirag et al. (2010) consider a similar fairness-concerned model as Cui et al. (2007) with nonlinear demand. Pavlov and Katok (2009) build a model of coordinating contracts with fairness preferences and find that incomplete information about fairness preferences result in rejections. Katok and Pavlov (2013) investigate the causes of three factors, i.e., inequality aversion, bounded rationality and incomplete information, on the inefficiency of coordinating a simple supplier - retailer channel. The main result is that incomplete information about the retailer's degree of inequality aversion plays a more important role than bounded rationality in explaining the suppliers' behavior. Pavlov and Katok (2009) build a new model of fairness concern which is distinct from previous studies in that it treats fairness concerns as the private information of players.

Loch and Wu (2008) design a two-player sequential move game in which two participants can interact repeatedly over multiple rounds. It requires that participants choose a profit margin at which to sell a product to a market. In each round, player A (the first mover) chooses his/her margin p_A, and then player B (the second mover) chooses his/her p_B given the player A's decision. The two margins jointly determine the market price, $p = p_A + p_B$. Demand q is a linear function of the market price. They implement the game with three experimental conditions. In the control condition, all players are anonymous, separated throughout the study (they interact through computer screens), and prevented from communicating. The second experimental condition implies a salient relationship by the way of exchanging names, shaking hands (without any further communication during the game) before the start of the game. In the last condition, a participant is declared the "winner" of a given round on the screens if he/she earns a higher profit than his/her partner, by this way, the preference for status can be salient. Subjects consistently deviate from rational, profit-maximizing behavior in all conditions, which suggests that social preferences can shift the equilibrium behavior. Moreover, the second mover's prices exhibit a positive correlation with the first-mover's prices, which is not consistent with the economic model of rational decision makers since it posits that the second mover has no credible counteraction after an aggressive first-mover's action, and therefore should give in.

Wang and Webster (2009) model manager's decision-making behavior in the SPP based on the assumption of loss aversion. They find that loss-averse newsvendor's optimal order quantity may increase in wholesale price and decrease in retail price, which can never occur in the risk-neutral newsvendor model. Ma et al. (2012) extend the model with two ordering opportunities and market information updating. Liu et al. (2013) investigate a newsvendor game in which two substitutable products are sold by two different retailers (newsvendors) with loss-averse preferences. Ho et al. (2010) propose a behavioral theory, which rests on a well-known stylized fact of human behavior that people's preferences are reference-dependent, to predict actual ordering behavior in multilocation inventory systems. They incorporate reference dependence into the newsvendor framework by assuming that there are psychological costs of leftovers and stockouts and the psychological aversion to leftovers is greater than the disutility for stockouts. Still some scholars investigate the newsvendor problem by considering other behavioral factors, such as overconfidence (Ren and Croson, 2013), bounded rationality (Su, 2008), regret theory (Schweitzer and Cachon, 2000), cognitive reflection (Moritz et al., 2013).

Chapter 3

Newsvendor Model for a Dyadic Supply Chain with Nash Bargaining Fairness Concerns *

This chapter investigates the newsvendor problem for a dyadic supply chain in which both the supplier and the retailer have the preferences of status seeking with fairness concerns. Nash bargaining solution is introduced as the fairness reference point and equilibrium results are derived. The effects of fairness-concerned status-seeking behaviors on optimal decisions as well as channel efficiency are further analyzed. It is shown that the channel efficiency will decrease because of such behavioral preference. The retailer's share will be larger when the supplier concerns fairness less, and the supplier's sensitivity to fairness plays a relatively more important role for the channel efficiency. Additionally, another interesting managerial insight is concluded that fairness concerns will not change the status of channel coordination in certain conditions. More specifically, those contracts are able (unable) to coordinate fairness-neutral supply chain, based on affine transformations with scale factors within certain ranges, still succeed (fail) to coordinate the fairness-concerned. Incorporating the preference of fairness concern into the

*This chapter is primarily referenced from: Shaofu Du, **Tengfei Nie**, Chengbin Chu, and Yugang Yu (2014). Newsvendor model for a dyadic supply chain with nash bargaining fairness concerns. International Journal of Production Research, 52(17): 5070-5085. DOI: 10.1080/00207543.2014.895446.

supply chain won't change the conditions of coordination, but it has great impact on the difficulty of coordinating the channel.

3.1 Introduction

This chapter studies the newsvendor problem in which a supplier deals with a retailer. Both of them are assumed to have the preference of status seeking, which means they have the desires for a higher relative payoff compared with the other party's (Loch and Wu, 2008). Such preference is proved to be pervasive among human beings (Easterlin, 1974, 1995; Clark and Oswald, 1996) and there are numerous researches about it (Kawamoto, 2009; Jaeger, 2004). The main features are the integration of fairness concern and the use of Nash bargaining solution as a fairness reference point. These features make this research relevant, since, as we can see later, (1) the studies about fairness concern are still scarce despite the fact that such a model is much closer to reality than traditional studies based on rationality assumptions; (2) it answers the question of fairness reference by using the Nash bargaining equilibrium as a reference.

There are abundant evidences and examples to show that individuals as well as firms pay more and more attentions to fairness in real life, i.e. fairness concerns (Fehr and Schmidt, 1999; Su, 2008). People not only are concerned about their self-interests, but also care about other people's benefits (Rabin, 1993). With fairness concerns, one may punish his (her) collaborator at the cost of decreasing his (her) own interests when unfairness is perceived. The behavioral preference of fairness concern is incompatible with traditional utility theory since it is against the basic assumption that people are rational, while the existence of fairness preference is supported by many empirical studies and experiments. Many studies about Ultimatum Game (e.g., Camerer and Thaler, 1995; Güth, 1995; Thaler, 1988; Ruffle, 1998) have derived similar results that the responder will refuse the proposal for inequality, even if the proposal provides him with a larger profit. Kahneman et al. (1986b) show that consumer and employee are both fairness concerned for price and salary respectively, in the process of market transactions. They also point out that organizations have the same preference just like individuals in many cases. Ho and Su (2009) analyze two independent ultimatum games played sequentially by a leader and two followers by considering peer-induced fairness between followers and distributional fairness between the leader and followers.

Fairness concerns are generally formalized by incorporating profit disparity into decision-maker's utility function. Bolton (1991) and Rabin (1993) believe that both positive and negative inequalities will influence individuals' utilities. Konrad and Lommerud (1993) introduce relative standing comparisons, or "status seeking" into their utility functions from the perspective of social level. de Bruyn and Bolton (2008) improve the asymmetric loss function and investigate the influence of fairness considerations on bargaining. The results show that their model, in which the decision-makers are assumed to be fairness concerned and have bounded rationality, is in line with the empirical or experimental data. They conclude that out-of-sample forecasts offer better predictions than traditional preference models that ignore fairness considerations. Extant literatures have insufficiently take into consideration the choice of fairness reference of supply chain members. Fehr and Schmidt (1999) develop a fairness model (namely "F-S model") in which the equitable standard is responder's outcome. It is reasonable under their theoretical framework since they investigate simple games such as ultimatum game and public game. However, this kind of fairness reference has its limitations in reality. One with less competitive power or cooperative contribution may not expect the same outcome with his (her) partner, and vice versa. Therefore, based on F-S model, Cui et al. (2007) take into account the specific environment of supply chain. In their paper, two free parameters, i.e., μ and γ, are introduced into the utility functions. That is, the supplier and the retailer respectively regard μ times and γ times of other's profit as fair outcome, which makes their model closer to reality. When studying the effects of social preferences on the performance of a dyadic supply chain, Loch and Wu (2008) put forward a simpler utility with fairness concerns for each player i (called L-W model apart from F-S model): $U_i = \pi_i + \theta_i \pi_j$, where π_i denotes the material payoff, and θ_i is called *other-regarding parameter*. The other-regarding parameters are updated through reciprocity and status updates. Most studies on fairness concerns so far have similar structures to these models. However, an important issue is still left behind that the exogenous other-regarding parameters cannot capture power and contribution endogenously and therefore affect the fairness perception.

To address this issue, Nash bargaining solution is used as fairness reference to formally depict perceptively fair compromise in this chapter, which is a new perspective to study fairness concerns in a supply chain. According to Nash (1950, 1953), we may regard Nash bargaining solution as representing all anticipations that the two bargainers might agree upon as fair bargains. Nash bargaining solution is characterized by a set of axioms (i.e., Pareto efficiency, Symmetry, Invariant to affine transformations and Independence of irrelevant alternatives) that are appealing in defining fairness (Nash, 1950, 1953; Osborne and Rubinstein, 1994; Touati et al., 2006). It is the unique scale-invariant solution which satisfies the property that balancing fairness and efficiency if each player's payoff lies between the minimum and maximum of the payoffs assigned to him by the egalitarian and utilitarian solutions in 2-person bargaining problem (Rachmilevitch, 2011). It gives how much one should deserve from the "bargaining pie"(overall material payoff). Therefore, Nash bargaining solution can been seen as a natural extension of the proportional fairness criterion which is probably the most popular fairness notion (Mazumdar et al., 1991; Yaïche et al., 2000). In long-term interactions, both sides will gradually come into consensus about the fairness reference of Nash bargaining solution, even though there is not real bargaining process. Note that the Nash bargaining process is just a *psychological game* for fairness perception that is more likely to lie in the decision-makers' mind than really happen.

Inspired by the L-W model, we build a new behavioral model by introducing Nash bargaining fairness reference. In our model, the utility function of each side can be expressed by Eq. (3.1) in Section 2. The fairness reference can be formulated in two alternative forms, i.e., the perceptively fair material payoffs 'from the overall pie' and 'per unit pie', namely *absolute* and *relative* fairness references respectively. The relative form seems more intelligible and persuasive than the absolute one, since it means a fair proportion regardless of the pie size. In practice, the benefit distribution is not necessarily realized in line with such rule, then unfairness is perceived. On the one hand, the gain less than the fairness reference will reduce the utility and the sensitivity to the gap is captured by the fairness concern parameter λ_i, which is similar to the other-regarding parameter θ_i in the L-W model. On the other hand, the fairness reference derived from Nash bargaining game implies that the player would not pursue self-interest without considering the partner's welfare. The main difference between L-W and our models is fairness reference.

Our analysis shows that in a dyadic supply chain, the channel efficiency will decrease because of fairness concerns. The retailer's share will be larger when the supplier concerns fairness less, and the supplier's sensitivity to fairness plays a relatively more important role in alleviating double marginalization and improving the channel efficiency. Additionally, another interesting managerial insight is concluded that fairness concerns will not change the status of channel coordination in certain conditions. More specifically, those contracts able (unable) to coordinate fairness-neutral supply chain, based on affine transformations with scale factors within certain ranges, still succeed (fail) to coordinate the fairness-concerned.

The rest of this chapter is organized as follows. In Section 3.2, we will show how to get Nash bargaining solution in the dyadic supply chain. In Section 3.3, the normative results of fairness-neutral channel where only monetary payoffs matter are given as a benchmark for the later discussion about fairness-concerned channel. Section 3.4 establishes the behavioral model with Nash bargaining fairness concerns. Section 3.5 provides a numerical analysis and concludes the main impact of fairness concerns on the supply chain. In Section 3.6, we summarize our conclusions.

3.2 Modelling fairness concerns with Nash bargaining reference

For a fairness-concerned firm with the preference of status seeking, its utility depends on the realized benefit as well as the gap to the fairness reference. For the sake of simplicity and without loss of generality, a linear form is used to formulate the utility of each member in a dyadic supply chain as follows.

$$u_i = \pi_i + \lambda_i (\pi_i - \bar{\pi}_i) = [\rho_i + \lambda_i (\rho_i - \bar{\rho}_i)] \pi, i = s, r \tag{3.1}$$

where the subscripts $i = s, r$ refer to the supplier and the retailer. $\lambda_i > 0$ is the i's fairness concern parameter. π_i and ρ_i represent the i's realized material payoff and the proportion to the overall channel's material payoff (denoted by π), while $\bar{\pi}_i$ and $\bar{\rho}_i$ represent the i's *absolute* and *relative* references for fairness perception respectively. It is known that $\pi_r + \pi_s = \pi$ and $\rho_r + \rho_s = 1$. Since the absolute and relative fairness references come from the psychological Nash bargaining for the fair distribution of channel material payoff between two players, they must satisfy the Pareto efficiency axiom, therefore $\bar{\pi}_r + \bar{\pi}_s = \pi$ and $\bar{\rho}_r + \bar{\rho}_s = 1$ hold as well.

The above utility function consists of two parts. The former is material payoff term that is the only part considered by traditional studies. The latter term depicts fairness concern. The fairness concern parameter, λ_i, can be interpreted as one of the i's inherent properties that is independent of its relative power and contribution. It is an individual parameter which captures the strength of the i's fairness concern preference. The higher is λ_i, the more important is the fairness concern utility compared with the utility arising from the material payoff. Note that if λ_i is zero, the i's utility is equal to his/her material payoff. Then the model is reduced to the traditional case.

Lemma 3.1. *The fairness references depends on the fairness-concerned degree of both sides. The more one (or the less its counterpart) concerns fairness, the higher is its reference for fairness perception, and vice versa. Formally, the relative fairness references for the supplier and the retailer satisfy*

$$\begin{cases} \bar{\rho}_r = \frac{\alpha(1+\lambda_r)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s} = \frac{\alpha\Lambda_r}{\Lambda_s+\alpha(\Lambda_r-\Lambda_s)} \\ \bar{\rho}_s = \frac{(1-\alpha)(1+\lambda_s)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s} = \frac{(1-\alpha)\Lambda_s}{\Lambda_s+\alpha(\Lambda_r-\Lambda_s)} \end{cases} \tag{3.2}$$

where, and hereafter, $\Lambda_i \equiv 1+\lambda_i$, $i = s,r$, is introduced for the sake of simplicity.

Proof. To derive the relative fairness references for both sides, just consider their utilities per unit pie (denoted by v_i).

$$v_i = \rho_i + \lambda_i\left(\rho_i - \bar{\rho}_i\right), i = s,r \tag{3.3}$$

According to Nash's axiomatic definition (Nash, 1950, 1953; Osborne and Rubinstein, 1994; Binmore et al., 1986), Nash bargaining solution $(\bar{\rho}_s, \bar{\rho}_r)$ is the partition (ρ_s, ρ_r) that maximizes the Nash product $(v_r)^{\alpha}(v_s)^{1-\alpha}$ as follows.

$$\begin{aligned} \max_{\rho_r,\rho_s} \quad & \Psi \equiv (v_r)^{\alpha}(v_s)^{1-\alpha} \\ s.t. \quad & \rho_r + \rho_s = 1; \\ & \rho_r, \rho_s \in [0,1]. \end{aligned} \tag{3.4}$$

where $0 < \alpha < 1$ denotes the retailer's bargaining power and $(1-\alpha)$ the supplier's.

Substituting Eq. (3.3) into the Nash product yields

$$\begin{aligned} \Psi &= \left[\rho_r + \lambda_r\left(\rho_r - \bar{\rho}_r\right)\right]^{\alpha}\left[\rho_s + \lambda_s\left(\rho_s - \bar{\rho}_s\right)\right]^{1-\alpha} \\ &= \left[\rho_r + \lambda_r\left(\rho_r - \bar{\rho}_r\right)\right]^{\alpha}\left[1 - \rho_r + \lambda_s\left(\bar{\rho}_r - \rho_r\right)\right]^{1-\alpha} \end{aligned} \tag{3.5}$$

After taking the second derivative of Eq. (3.5) with respect to ρ_r , we have $\partial^2\Psi/\partial{\rho_r}^2 < 0$. Hence, Ψ is strictly concave in ρ_r. There exists a unique optimal solution, i.e. $\bar{\rho}_r$, that satisfies the first-order condition Eq. (3.6).

$$-\frac{\alpha(1+\lambda_r)}{\rho_r + \lambda_r(\rho_r - \bar{\rho}_r)} + \frac{(1-\alpha)(1+\lambda_s)}{1 - \rho_r + \lambda_s(\bar{\rho}_r - \rho_r)} = 0 \tag{3.6}$$

Additionally, we have $\rho_r = \bar{\rho}_r$ at the equilibrium. After combining Eqs. (3.5) and (3.6) and making some algebraic calculations, we derive the Nash bargaining solution $(\bar{\rho}_s, \bar{\rho}_s)$ establishing Eq. (3.2). □

3.3 Normative results of fairness-neutral channel

We study a dyadic supply chain with a single supplier and a single retailer in a single-period, stochastic demand (newsvendor) setting, in channel-related researches such as Cachon (2003), Taylor (2002), etc. The supplier offers to the retailer products with a unit production cost of c and charges a wholesale price w. The retailer responds by an order quantity q. The demand D during the selling season is stochastically distributed with p.d.f. $f(\cdot)$ and c.d.f. $F(\cdot)$. Let $\bar{F}(\cdot) \equiv 1 - F(\cdot)$. The unit retail price, denoted as p is fixed. Positive inventory by the end of season, if any, is destroyed at no cost. In case of shortage, there is no additional cost than the sale loss. As a consequence, the profits of the retailer, the supplier and the whole channel are given respectively by

$$\pi_r = pS(q) - wq \tag{3.7}$$

$$\pi_s = (w - c)\,q \tag{3.8}$$

$$\pi = \pi_r + \pi_s = pS(q) - cq \tag{3.9}$$

where $S(q) = \int_0^q \bar{F}(y)dy$ represents the expected sale.

According to the traditional normative theories, the individually and globally optimal order quantities in the decentralized and centralized cases, denoted by q^* and q^o, satisfy the first-order conditions of Eqs. (3.7) and (3.9) respectively as follows.

$$\frac{\partial \pi_r}{\partial q}(q^*) = p\bar{F}(q^*) - w = 0 \tag{3.10}$$

$$\frac{\partial \pi}{\partial q}(q^o) = p\bar{F}(q^o) - c = 0 \tag{3.11}$$

Consequently, we have the retailer's optimal order quantity q^* that satisfies Eq. (3.12) and the supplier's corresponding optimal wholesale price w^* establishing Eq. (3.13) as follows.

$$p\bar{F}(q^*)\,[1 - g(q^*)] = c \tag{3.12}$$

$$w^* = p\bar{F}(q^*) \tag{3.13}$$

where $g(x) \equiv xf(x)/\bar{F}(x)$, namely *generalized failure rate (GFR)* function. Increasing generalized failure rate (IGFR) distributed demand is inherited from many well-known supply chain related literatures (such as Cachon, 2003; Lariviere and Porteus, 2001, etc.)[1]. According to Lariviere and Porteus (2001), we can guarantee that the term $[1-g(q^*)]$ is non-negative.

3.4 Behavioral model with Nash bargaining fairness concerns

What we mainly concern is the fairness-concerned scenario. Therefore, the above normative results of fairness-neutral channel will be used as a benchmark for comparison. In the following discussion on fairness-concerned supply chain, the background remains the same except that both the supplier and retailer have fairness preferences. In the rest of this chapter, notations with subscript f, q_f^* for instance, represent the "fairness-concerned" in contrast to the "fairness-neutral" in Section 3.3, where no subscript is used.

3.4.1 Newsvendor's optimal response to wholesale price

This section will discuss the retailer's optimal response to a given wholesale price. How relevant factors lead to decision bias is discussed in detail. Two motivations make us provide discussion of this part. Firstly, it prepares for the latter discussion on the equilibrium. In this sense, it is the first step of backward induction for the Stackelberg game. Secondly, it is still worth discussing even if the wholesale price is given exogenously rather than determined by the supplier. Fairness preferences do make sense as well.

Incorporating Nash bargaining reference of Eq. (3.2) into Eq. (3.1) yields

$$u_r = (1+\lambda_r)\left(\pi_r - \frac{\alpha\lambda_r}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\pi\right) \tag{3.14}$$

Substituting Eqs. (3.7) and (3.9) into Eq. (3.14), and taking the first- and second-order derivatives of u_r with respect to q, we have

$$\frac{\partial u_r}{\partial q} = (1+\lambda_r)\left[p\bar{F}(q) - w - \frac{\alpha\lambda_r}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}(p\bar{F}(q)-c)\right]$$

[1] Distributions with a property that the GFR function $g(q)$ is increasing in their probability spaces are called increasing generalized failure rate (IGFR) distributions, which captures most common distributions and is widely used in stochastic demand (Lariviere and Porteus, 2001). More information about IGFR refers to Cachon (2003) and Du et al. (2011).

$$\frac{\partial^2 u_r}{\partial q^2} = (1+\lambda_r)\left[-1+\frac{\alpha\lambda_r}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right] pf(q) < 0$$

Hence, the retailer's utility function is strictly concave in q, and therefore there exists a unique optimal order quantity q_f^* that maximizes the expected utility and satisfies the first-order conditions as follows.

$$p\bar{F}(q_f^*)\left[\frac{1+\lambda_s-\alpha\lambda_s}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right] = w - \frac{\alpha\lambda_r}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}c \tag{3.15}$$

Proposition 3.1. *For any $\lambda_r > 0, \lambda_s > 0$, the fairness-concerned retailer's optimal order quantity is smaller than its fairness-neutral counterpart, which is smaller than the fairness-neutral channel's optimal quantity*

$$q_f^* < q^* < q^o \tag{3.16}$$

Proof. Since $\lambda_r > 0, \lambda_s > 0$ and $w > c$, It is not difficult to know from Eq. (3.15) that $p\bar{F}(q_f^*) - w = [(w-c)\alpha\lambda_r] / (1+(1-\alpha)\lambda_s) > 0$. Recalling Eq. (3.10), we have $p\bar{F}(q_f^*) - w > p\bar{F}(q^*) - w$, and thus $F(q_f^*) < F(q^*)$. Hence,

$$q_f^* < q^*$$

Similarly, it can be derived from Eqs. (3.10) and (3.11) that $F(q^*) < F(q^o)$. Then,

$$q^* < q^o$$

Therefore, we have Eq. (3.16). □

By making comparison between fairness-concerned and fairness-neutral cases, Proposition 3.1 shows that the ordering decision is biased by fairness concerns, as coincides with intuitive reasoning. Therefore, the efficiency of a decentralized channel decreases to a lower level. From Eq. (3.15) in contrast to Eq. (3.10), we can conclude the reason that the double marginalization effect is magnified by fairness concerns. Proposition 3.2 makes a more specific investigation.

Proposition 3.2. *The retailer's optimal order quantity has the following relationship with the fairness concern parameters. For any $\lambda_r > 0, \lambda_s > 0$,*

1. *q_f^* is decreasing in λ_r. If λ_r tends to 0, q_f^* approaches to q^*;*

2. *q_f^* is increasing in λ_s. If λ_s tends to $+\infty$, q_f^* approaches to q^*.*

3. *q_f^* is increasing in unit production cost c.*

Proof. By the implicit function theorem, it is known that

$$\frac{\partial q_f^*}{\partial \lambda_r} = -\frac{\partial^2 u_r(q_f^*)}{\partial q \partial \lambda_r} \Bigg/ \frac{\partial^2 u_r(q_f^*)}{\partial q^2} = \frac{(w-c)\alpha}{(-1-\lambda_s+\alpha\lambda_s)pf(q_f^*)} < 0$$

Similarly, it can be obtained that

$$\frac{\partial q_f^*}{\partial \lambda_s} = \frac{(w-c)(1-\alpha)\alpha\lambda_r}{(-1-\lambda_s+\alpha\lambda_s)^2 pf(q_f^*)} > 0$$

$$\frac{\partial q_f^*}{\partial c} = -\frac{\partial^2 u_r(q_f^*)/\partial q \partial c}{\partial^2 u_r(q_f^*)/\partial q^2} = \frac{\alpha\lambda_r}{1+\lambda_s(1-\alpha)pf(q_f^*)} > 0$$

Particularly, when $\lambda_r \to 0$ or $\lambda_s \to +\infty$, Eq. (3.14) is reduced to $u_r = (1+\lambda_r)\pi_r$, i.e. u_r becomes a positive linear transformation of π_r, and accordingly Eq. (3.15) is reduced to Eq. (3.10). □

Point 1 suggests that the more the retailer concerns fairness, the more he ('she' refers to the supplier and 'he' refers to the retailer in the supply chain throughout this chapter) is conservative in ordering quantity. In other words, when the retailer pays more attention to fairness, the fairness-concerned term accounts more in his total utility and the supplier has more difficulty to satisfy the retailer's requirement. Therefore, the retailer will order less to punish the supplier. Particularly, it is worth noting that a fairness-neutral retailer's order quantity is independent of the supplier's fairness concern parameter. What the fairness-neutral retailer concerns is just in maximizing its profit as much as possible.

Point 2 implies a reverse result to the above trend. It indicates that the more the supplier cares about fairness the more the retailer will order, because the retailer is obliged to satisfy the supplier's higher claim to a certain degree. Recalling Eq. (3.2), we know that $\bar{\pi}_r$ decreases with λ_s. That is, If the supplier gets more sensitive to fairness, the retailer lowers its fairness reference, and thus its marginal utility increases, which will make him order more. From another perspective, we can say that the retailer feels he gets a fair treatment and thus will increase his order approaching to q^*. Additionally, the change of λ_s can compensate for the simultaneous reverse change of λ_r, and vice versa.

Point 3 shows that the retailer's optimal order have nothing to do with the unit production cost in the fairness-neutral channel, while they move consistently in same directions in the fairness-concerned. The possible explanation may be as follows. In the fairness-neutral channel, the retailer just cares about its own profit. In the fairness-concerned channel, however, the retailer also focuses on the whole supply chain's profit in order to know if he is fairly treated. Lower unit production cost results in higher channel profit. Accordingly, the retailer has a higher perception of unfairness for lower share and therefore orders less. Conversely, the retailer will purchase more to compensate the supplier for increasing production cost. Kahneman et al. (1986b) investigate the fairness as a constraint on profit seeking. Their result of questionnaire shows that the hardware store is considered unkind to raise the price during a blizzard because it takes advantage of the short-run increase in demand, while the similar action of a grocer is more acceptable due to wholesale price has increased with a transportation mixup.

Let u denote the overall channel's utility, then by combining Eqs. (3.1) and (3.2), we have

$$u = \Lambda_r \pi_r + \Lambda_s \pi_s - \frac{\alpha \Lambda_r (\Lambda_r - 1) + (1-\alpha)\Lambda_s(\Lambda_s - 1)}{\Lambda_s + \alpha(\Lambda_r - \Lambda_s)} \pi \tag{3.17}$$

Proposition 3.3. *The utility function of a fairness-concerned channel is strictly concave in q if $\lambda_r > \lambda_s$, and there exists a unique optimal order quantity q_f^o that maximizes the overall utility and satisfies the following first-order condition.*

$$p\bar{F}(q_f^o) - c = \frac{(\Lambda_r - \Lambda_s)\,[\Lambda_s + \alpha(\Lambda_r - \Lambda_s)]}{\Lambda_s - (\Lambda_r - \Lambda_s)\,(\alpha(-1+\Lambda_s) - \Lambda_s)} (w - c) \tag{3.18}$$

Proof. The first- and second-order derivatives of Eq. (3.17) regarding q is derived as follows.

$$\frac{\partial u}{\partial q} = \frac{\Lambda_s - (\Lambda_r - \Lambda_s)\,(\alpha(-1+\Lambda_s) - \Lambda_s)}{\Lambda_s + \alpha(\Lambda_r - \Lambda_s)} [p\bar{F}(q) - c] + (\Lambda_s - \Lambda_r)\,[w - c] \tag{3.19}$$

$$\frac{\partial^2 u}{\partial q^2} = \left[\frac{\alpha(\Lambda_r - \Lambda_s)(-1+\Lambda_s) + \Lambda_s(-1 - \Lambda_r + \Lambda_s)}{\Lambda_s + \alpha(\Lambda_r - \Lambda_s)} \right] pf(q) < 0$$

Hence, the overall utility of the fairness-concerned channel is strictly concave in q. One unique optimal order quantity q_f^o exists and satisfies Eq. (3.18). □

Recent market structure reviews have shown a shift of retailing power from manufacturers to retailers (Huang and Li, 2001). In this case, the retailer may have a larger fairness reference and concerns fairness more. We can further investigate the value range of q_f^o in this case.

Recalling Eqs. (3.11) and (3.18), we have $p\bar{F}(q_f^o) - c > p\bar{F}(q^o) - c$, and thus $q_f^o < q^o$. Moreover, integrating Eq. (3.15) with Eq. (3.19) yields $\frac{\partial u(q_f^*)}{\partial q} = \frac{\Lambda_s(w-c)}{1+(1-\alpha)(\Lambda_s-1)} > 0$. Then, the concavity of the overall utility function leads to $q_f^* < q_f^o$. Taken together, $q_f^* < q_f^o < q^o$, but it is uncertain whether q_f^o is larger than q^* or not.

3.4.2 Equilibrium results

This section discusses the optimal strategy of the supplier by charging a wholesale price. The impact of the fairness concerns on the payoff of each player is analyzed as well.

Eq. (3.15) implicitly gives an optimal order quantity for the retailer at a given wholesale price, i.e. the retailer's best response $q(w)$ to the supplier's decision w. The inverse function of $q(w)$ can be derived from Eq. (3.15) as:

$$w(q) = p\bar{F}(q)\left[\frac{1+\lambda_s-\alpha\lambda_s}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right] + \frac{\alpha\lambda_r}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}c \tag{3.20}$$

Then the fairness-concerned supplier's utility is

$$u_s(q,w(q)) = (1+\lambda_s)\left[(w(q)-c)q - \frac{\lambda_s(1-\alpha)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}(pS(q)-cq)\right] \tag{3.21}$$

Proposition 3.4. *Under decentralized channel with fairness concerns, the unique equilibrium solution consisting of the supplier's optimal wholesale price w_f^* and the retailer's best response q_f^* must satisfy*

$$w_f^* = \frac{(1+\lambda_s-\alpha\lambda_s)\,p\bar{F}(q_f^*) + \alpha\lambda_r c}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s} \tag{3.22}$$

$$p\bar{F}(q_f^*)\left[1-g(q_f^*)(1+(1-\alpha)\lambda_s)\right] = c \tag{3.23}$$

where $g(\cdot)$ is the GFR function as appeared first in Eq. (3.12) .

Proof. See Appendix A.1.1. □

Proposition 3.5. *In the fairness-concerned channel, the supplier's optimal wholesale price w_f^* and the corresponding retailer's optimal order quantity q_f^* has the following relationship with the fairness concern parameters:*

1. *w_f^* is decreasing in λ_r , the corresponding q_f^* will not be affected by λ_r;*

2. *w_f^* is increasing in λ_s , while the corresponding q_f^* is decreasing in λ_s;*

Proof. See Appendix A.1.2. □

Therefore, the more attention the retailer pays to fairness, the lower wholesale price the supplier charges, but the fairness concern of the retailer has no impact on his order quantity. On the contrary, the more the supplier cares about fairness, the higher wholesale price she will charge, which is the reason that the retailer's optimal order quantity tends to be conservative.

3.5 The impact of fairness concerns on the supply chain

In this section, firstly, a numerical example is given to show the impacts of the supplier's fairness concern and the retailer's fairness concern on some important measures, such as the profits and the supply chain's efficiency. Then the influence of members' fairness concerns on channel coordination is also discussed.

When the supplier and the retailer are both fairness-concerned, according to Proposition 3.4, we can easily get the supplier's optimal wholesale price w_f^* and the retailer's optimal order quantity q_f^*. For the convenience of simplification, like Cachon (2003), we take power function distribution with a shape parameter k for example (refer to Appendix A.2 for detailed derivation). For the power function demand, the shape parameter k can be interpreted as the scale of market, since the mean is increasing in k. The supplier's profit share, $\zeta \equiv \pi_s(q_f^*, w_f^*)/\pi(q_f^*)$ and the efficiency of the contract, $\delta \equiv \pi(q_f^*)/\pi(q^o)$ are two performance measures applied to the wholesale price arrangement. From the supplier's perspective, she hopes both of them are high: the product of the two ratios is the supplier's share of the supply chain's optimal profit (Cachon, 2003). Therefore, we would like to analyze the influence of several important variables on them first.

Table 3.1 shows that both the efficiency of contract δ and the supplier's share ζ are increasing in k. When k increases to a large number, say 100, the efficiency can reach higher than 96 percent, but the supplier's share increases too. Therefore, it would be interesting to consider which one, δ or ζ, increases more quickly. Figure 3.1 is used to illustrate this issue. In this figure, four cases, labeled by (a), (b), (c) and (d) respectively, are considered and each case includes three scenarios: $\lambda_r < \lambda_s$, $\lambda_r = \lambda_s$ and $\lambda_r > \lambda_s$. Taking Subfigure 3.1.a for example, we assign $\lambda_r = 20$, $\lambda_s = 1$ for $\lambda_r > \lambda_s$, $\lambda_r = 1$, $\lambda_s = 20$ for $\lambda_r < \lambda_s$, and $\lambda_r = 20$, $\lambda_s = 20$ for $\lambda_r = \lambda_s$. Subfigure 3.1.a shows the results of the three scenarios when k increases from 0 to 10 and $\alpha = 0.3$. Subfigures 3.1.b and 3.1.c have similar explanation. The last one displays the

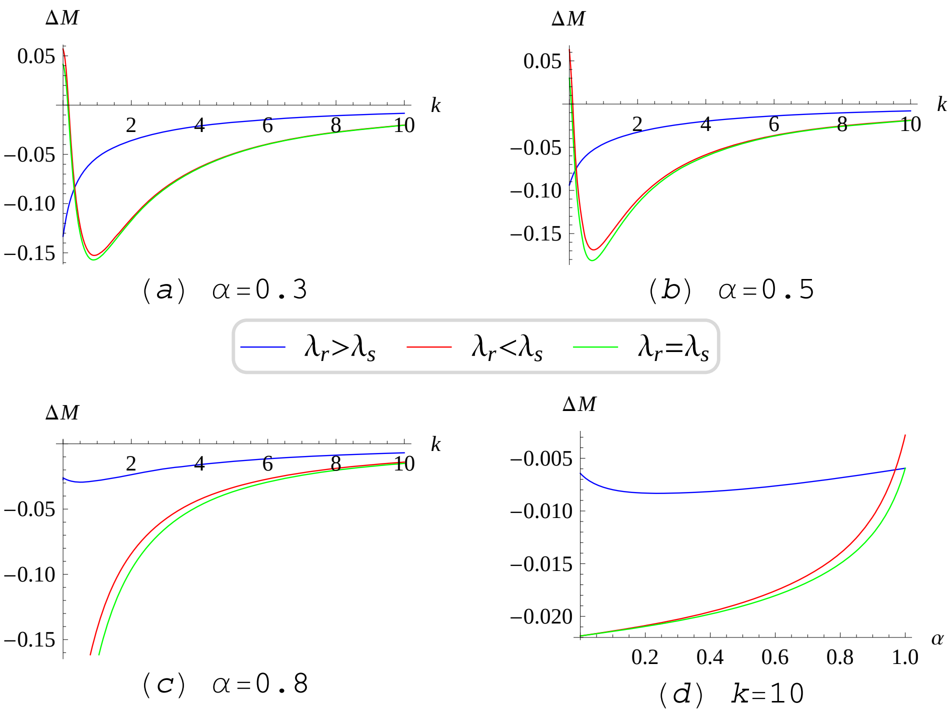

Figure 3.1: Marginal difference between the supplier's share ζ and the channel efficiency δ

results of the three situations when α increases from 0 to 1 and $k = 10$. In this chapter, the term of "marginal difference" is employed to denote how much the supplier's marginal share is greater than the channel's marginal efficiency, i.e. the difference between the supplier's share and the channel efficiency in terms of increasing speed, or formally $\Delta M \equiv \frac{\partial \zeta}{\partial k} - \frac{\partial \delta}{\partial k}$. We call the positive marginal difference as "excess". According to Cachon (2003), when the distribution parameter k changes from 0.2 to 3.2, the so-called "excess" will arise. However, our result is different. With the increase of the market scale k, the supplier's share increases less quickly than the channel efficiency unless k is very small. More specifically, there are three necessary conditions in which the "excess" occurs as shown in Figure 3.1. (1) The market scale is tiny, (2) the supplier is not less fairness-concerned than the retailer, and (3) the supplier has bigger bargaining power. Additionally, Subfigure 3.1.d shows that the "excess" would not happen with the increase of the retailer's bargaining power when the market scale is not tiny enough. Moreover, we can find that the change of λ_r has little influence on the marginal difference while that of λ_s is significant.

Moreover, we can compare Table 3.2 with Table 3.3 to show the influence of fairness concern parameters on the profit share and efficiency. The result tells us that the more he(she) is fairness-concerned, the higher share he(she) will get. By Table 3.4, it seems that the share will not change and at the same time, the efficiency will decrease very quickly if both of them are

Table 3.1: Sensitivity of the performance to the market scale under the power function demand (case 1)

Distribution parameter, k	0.6	1.5	2.6	3.3	4.0	100
Efficiency, δ	60.05%	65.66%	70.16%	72.31%	74.10%	96.01%
Supplier's share, ζ	59.88%	66.75%	71.19%	72.99%	74.34%	83.34%

Note: $\lambda_s = 0.8$, $\lambda_r = 1.0$ and $\alpha = 0.3$.

Table 3.2: Sensitivity of the performance to the market scale under the power function demand (case 2)

Distribution parameter, k	0.6	1.5	2.6	3.3	4.0	100
Efficiency, δ	5.39%	19.97%	33.28%	39.52%	44.58%	93.88%
Supplier's share, ζ	94.12%	95.49%	96.26%	96.54%	96.75%	97.97%

Note: $\lambda_s = 20$, $\lambda_r = 1.0$ and $\alpha = 0.3$.

highly fairness-concerned. The result also implies that increase of k will be conducive to improve the efficiency. A possible explanation is as follows. When the scale of market k increases, which means demand augments, the supply chain profit will increase, the supplier and the retailer will not square accounts in every detail, just as the ultimatum game, both players tend to be more generous when facing a larger windfall.

Table 3.3: Sensitivity of the performance to the market scale under the power function demand (case 3)

Distribution parameter, k	0.6	1.5	2.6	3.3	4.0	100
Efficiency, δ	60.05%	65.66%	70.16%	72.31%	74.10%	96.01%
Supplier's share, ζ	14.73%	16.42%	17.52%	17.96%	18.29%	20.50%

Note: $\lambda_s = 0.8$, $\lambda_r = 20$ and $\alpha = 0.3$.

Table 3.4: Sensitivity of the performance to the market scale under the power function demand (case 4)

Distribution parameter, k	0.6	1.5	2.6	3.3	4.0	100
Efficiency, δ	5.39%	19.97%	33.28%	39.52%	44.58%	93.88%
Supplier's share, ζ	68.57%	69.57%	70.13%	70.34%	70.49%	71.38%

Note: $\lambda_s = 20$, $\lambda_r = 20$ and $\alpha = 0.3$.

By comparing Table 3.1 with Table 3.5 we notice that the efficiency of contract increases when the retailer has higher bargaining power. In other words, the decrease of the supplier's bargaining power will benefit the whole channel. The possible reason is that the supplier may

Table 3.5: Sensitivity of the performance to the market scale under the power function demand (case 5)

Distribution parameter, k	0.6	1.5	2.6	3.3	4.0	100
Efficiency, δ	69.82%	72.69%	75.50%	76.97%	78.24%	96.29%
Supplier's share, ζ	38.46%	44.01%	47.75%	49.30%	50.48%	58.68%

Note: $\lambda_s = 0.8$, $\lambda_r = 1.0$ and $\alpha = 0.8$.

have dominant power in the structure of Stackelberg game, she has the ability to control the whole channel when her bargaining power is high too. If this is the case, she will omit the retailer's feeling and thus maximize her own profit, which cause the failure of the channel's coordination. In short, it is important to balance the two members' power, especially when both parties are fairness concerned. Table 3.6 similarly demonstrates the increase of the retailer's bargaining power improves the channel efficiency. It is expected to see that the suppler's share will decrease with α.

Table 3.6: Sensitivity of the performance to the retailer bargaining power under the power function demand

Bargaining power of retailer, α	0.1	0.3	0.5	0.7	0.9	0.95
Efficiency, δ	95.92%	96.01%	96.12%	96.23%	96.36%	96.40%
Supplier's share, ζ	93.96%	83.34%	73.17%	63.41%	54.05%	51.77%

Note: $\lambda_s = 0.8$, $\lambda_r = 1.0$ and $k = 100$.

Table 3.7 summarizes the impacts of the supplier's fairness concern parameter λ_s, the retailer's fairness concern parameter λ_r and the retailer's bargaining power α on some important measures, such as the equilibrium and the supply chain's efficiency. The results show that the retailer's optimal order quantity q_f^*, the retailer's profit $\pi_r(q_f^*, w_f^*)$, the whole channel's profit $\pi(q_f^*)$ and the efficiency of the contract δ are decreasing in the supplier's fairness concern while w_f^* and the supplier's profit share ζ are increasing in it. Additionally, the impact of λ_s on the supplier's profit $\pi_s(q_f^*, w_f^*)$ and supplier's share of the supply chain's optimal profit η is not certain.It is worth noting that the impact of λ_s on the whole channel's profit and the efficiency of the contract is negative. However, the retailer's fairness concern has no influence on them. This tells us that the supplier's sensitivity to fairness may play a relatively more important role in the supply chain, which could be resulted from the dominant power that the supplier has under the Stackelberg setting. This result could also be possibly supported by the analysis of the influence of the retailer's bargaining power α on above two important measures. When the retailer has relatively higher bargaining power, both channel's profit and efficiency of the contract are in a high level. In addition, the more the supplier concerns about the fairness, the more aggressive she is, which is more likely to destroy the possibility of coordination. It tells us that it is not reasonable for the supplier to overemphasize the fairness. Sometimes, she may get more than what she wants if she is not going to haggle over every ounce. Table 3.7 also shows that the influence of the retailer's fairness concern on above measures is a little different from that of the supplier's. For example, the whole channel's profit and the efficiency of the wholesale price arrangement will not be affected by λ_r. This difference probably has something to do with their fairness concerns and the sequence of the game. Similarly, the more the retailer is fairness-concerned, the higher profit he will get and the lower the supplier's profit share will be. Furthermore, the player who has a higher bargaining power will benefit from it in general. However, Table 3.7 shows that the impact of α on the supplier's profit is uncertain, which means the supplier's profit may be increasing when the retail's bargaining power increases.

Table 3.7: Summary of the influence of fairness concern and bargaining power

	w_f^*	q_f^*	$\pi_r(q_f^*, w_f^*)$	$\pi_s(q_f^*, w_f^*)$	$\pi(q_f^*)$	δ	ζ	η
λ_r	$\searrow$	$\rightarrow$	$\nearrow$	$\searrow$	$\rightarrow$	$\rightarrow$	$\searrow$	$\searrow$
λ_s	$\nearrow$	$\searrow$	$\searrow$	$\otimes$	$\searrow$	$\searrow$	$\nearrow$	$\otimes$
α	$\searrow$	$\nearrow$	$\nearrow$	$\otimes$	$\nearrow$	$\nearrow$	$\searrow$	$\otimes$

Note: $\searrow$ and $\nearrow$ denote the result is decreasing and increasing in λ_r, λ_s or α respectively, $\rightarrow$ represents no influence, and $\otimes$ means that the impact is uncertain.

Based on above numerical results generated by varying parameter values, we can obtain some important insights, which are concluded in Observation 3.1.

Observation 3.1. *If both members of the fairness-concerned supply chain regard the Nash bargaining solution as their own fairness reference, it is impossible for a simple wholesale price arrangement to coordinate this supply chain; compared with fairness-neutral supply chain, the efficiency is likely to become lower in this channel; if the supplier has a relatively high fairness concern parameter, the retailer's utility probably worse off in the fairness-concerned supply chain.*

Observation 3.1 suggests that under the framework of Nash bargaining game, the fairness-concerned channel cannot be coordinated by the wholesale price arrangement. However, according to Cui et al. (2007), the supplier can use a simple wholesale price above her marginal cost to coordinate the fairness-concerned channel, though it can merely coordinate the channel in a small range. This might be explained as follows. Actually, we are considering fairness problem of the supply chain from different perspectives. The feature of decision-makers under our theoretical framework is if he (she) gets more than the fair reference profit, his (her) utility increases, and vice versa. It actually represents that they have a dominant preference, called status seeking. With the assumption of Cui et al. (2007), no matter what the decision-makers earn is higher or lower than the reference profit, his (her) utility will decrease, but it decreases less in the former situation. Therefore, their model implies that both the supplier and the retailer will not adopt radical action since an extravagant profit reduces his (her) utility. By comparing their model with ours, we conclude that fairness concern is not necessary to induce channel's coordination for those contracts that cannot coordinate traditional channel. The most important factor for channel's coordination is to what extent the decision-maker (especially prevailing party) will consider his (her) partner's feelings. In our model, the supply chain members do have mutual care because the Nash solution is derived by maximizing the product of both parties' utility. The extent of this kind of empathy, however, may be not enough and it is not evident in the process of bargaining game, which makes the channel fail to coordinate. The most important reason making the wholesale price arrangement impossible to coordinate the fairness-concerned channel lies in our utility framework of decision-makers. It is embodied in the supply chain members who have status-seeking preference that is dominant in the bargaining process. The experiment of Loch and Wu (2008) shows that the status condition always has the lowest efficiency while the relationship condition the highest efficiency. This is because status seeking induces more competitive behavior between the supplier and the retailer and reduces individual performance and overall efficiency, while a positive relationship promotes and maintains mutually beneficial actions for both sides. Just as Fershtman and Weiss (1998) pointed out, in those models of social status, which do not rely on a direct effect of status on utility and depend on a positive probability of long life and perfect foresight, such as Okuno-Fujiwara and Postlewaite (1995), social status is quite potent and efficiency is attainable. However, it is perhaps not surprising that in the framework of considering short lived agents with limited foresight and allowing the "blind" forces of evolution to select preferences, it is more likely to result in inefficiency.

Theorem 3.1. *The traditional coordinating (noncoordinating) contracts based on positive affine transformations with scale factors within certain ranges are still able (unable) to coordinate the fairness-concerned channel, no matter the coordinating goal is to maximize channel profit or channel utility. The constraints for scale factors are summarized as follows.*

1. *To coordinate the channel profit, the scale factor of affine transformation must be larger*

than $(\alpha\lambda_r)/(1+\alpha\lambda_r+(1-\alpha)\lambda_s)$*;*

2. *To coordinate the channel utility,*

$$ScaleFactor \in \begin{cases} \left(\frac{\alpha\lambda_r}{1+\alpha\lambda_r+(1-\alpha)\lambda_s}, \frac{1}{\lambda_s-\lambda_r}+\frac{\alpha(1+\lambda_r)}{1+\alpha\lambda_r+(1-\alpha)\lambda_s}\right), \ if\ \lambda_r < \lambda_s; \\ \left(\frac{\alpha\lambda_r}{1+\lambda_r}, +\infty\right), \ if\ \lambda_r = \lambda_s; \\ \left(0, \frac{1}{\lambda_s-\lambda_r}+\frac{\alpha(1+\lambda_r)}{1+\alpha\lambda_r+(1-\alpha)\lambda_s}\right) \cup \left(\frac{\alpha\lambda_r}{1+\alpha\lambda_r+(1-\alpha)\lambda_s}, +\infty\right), \ if\ \lambda_r > \lambda_s. \end{cases}$$

Proof. See Appendix A.3. □

Theorem 3.1 provides a generalized conclusion: the fairness-concerned channel can be coordinated by a contract if this contract can coordinate the fairness-neutral channel by positive affine transformations. Furthermore, we can derive three important managerial insights from Theorem 3.1 as follows.

(i) The constraint of coordination for fairness-concerned supply chain is stricter than that of fairness-neutral, no matter the coordinating goal is to maximize channel profit or channel utility. That is, it will be more difficult to coordinate the fairness-concerned channel. The reason, as we have analyzed above, is status-seeking preference of the supplier and the retailer that induces more intensified competition between them.

(ii) When incorporating fairness concerns into the supply chain, if the retailer is more fairness-concerned, it will be easier to coordinate a utility-seeking channel than a profit-seeking channel. However, if the supplier is more fairness-concerned, the utility-seeking channel becomes more difficult to be coordinated. In particular, the degree of difficulty of coordinating the two channels will be equal when the supplier and the retailer have the same level of fairness concern.

(iii) If the retailer has higher bargaining power, i.e., α increases, the profit-seeking channel is more difficult to coordinate since the lower bound of the scale factor becomes larger. This result is also true for utility-seeking channel when $\lambda_r = \lambda_s$. However, no matter which one is greater, λ_r or λ_s, the coordination of utility-seeking channel becomes relatively easier as the retailer's bargaining power increases, because the interval of the scale factor is shortened.

3.6 Concluding remarks

In this chapter, the individuals' fairness preferences in a dyadic supply chain are formalized by using Nash bargaining solution as the fairness reference, based on which a fairness-concerned model are established to develop behaviorial study of the newsvendor problem. Then, the equilibrium decisons are derived. The results show that the channel efficiency will decrease in the case of fairness concerns. The retailer(newsvendor)'s share will be larger when the supplier concerns fairness less, and the supplier's sensitivity to fairness plays a relatively more important role for the channel efficiency.

For a given(exogenous) wholesale price, fairness concerns lead to less order quantity in either decentralized or centralized decision. The decentrally optimal order quantity increases with the retailer's sensitivity to fairness while decreases with the supplier's sensitivity, and increases with the retail price as well as the unit production cost while decreases with the wholesale price. However, several changes arise when the supplier possesses the wholesale pricing power and takes the retailer's response into account. For example, fairness concerns result in less order quantity in decentralized while more in centralized decision. Therefore, the channel efficiency is further worse off. Besides, it is different from the scenario of the given wholesale price that the decentrally optimal order quantity keeps stationary with the retailer's sensitivity to fairness and decreases with the unit production cost.

Furthermore, the scale of market and the players' bargaining power may affect the supply chain performance. Particularly, the channel efficiency is increasing in the market scale and the retailer's bargaining power and therefore the double marginalization can to some extent be mitigated. The supplier's share is increasing in the market scale while decreasing in the retailer's bargaining power since the supplier's dominance is weakened. In the setting of Stackelberg-like game, the retailer generally benefit more from larger market scale and higher bargaining power. We use marginal difference between the supplier's share and the channel efficiency to investigate such issue, and call the positive marginal difference as "excess". The necessary conditions for the "excess" are that the market scale is tiny, and the supplier has larger bargaining power and concerns fairness not less than the retailer.

In addition, another interesting finding shows that the traditional coordinating (noncoordinating) contracts based on positive affine transformations are still able (unable) to coordinate the fairness-concerned channel, no matter the coordinating goal is to maximize channel profit or channel utility, if only the scale factor of affine transformation is assigned within a smaller interval rather than $[0, +\infty)$ required in the fairness-neutral case. It implies that the fairness preference makes the channel more difficult to be coordinated. That is, though the introduction of fairness concern into the supply chain won't change the conditions of coordination, it has great impact on the difficulty of coordinating the channel. Also, if the retailer (supplier) is more sensitive to fairness than the counterpart, it is more difficult to coordinate channel profit (utility) than utility (profit). Finally, if the retailer's bargaining power increases, the profit-seeking channel becomes more difficult to coordinate. It is also true for utility-seeking channel when the two members are equally fairness-concerned. However, when the two members are not equally fairness concerned, the coordination of utility-seeking channel can be achieved more easily.

Chapter 4

Reciprocal Supply Chain Considering Intention Impact*

The hypothesis of "economic man" of traditional economics is far from perfect. Models of fairness solely based on consequence can't explain why the same consequence of an action is perceived and reciprocated differently. A reciprocity model which accounts for both consequence and its underlying intention is presented in this chapter to illustrate the effect of intention in a traditional dyadic channel where one supplier plays a Stackelberg game with one retailer. This research aims to investigate how reciprocity may affect the members' decisions and the channel's coordination. In this study, two scenarios are discussed: (1) the retailer has a preference for reciprocity while the supplier doesn't; (2) both the retailer and the supplier have a preference for reciprocity. Additionally, acrimonious channel ($\gamma\mu > 1$) and harmonious channel ($\gamma\mu \leqslant 1$) are analyzed. Furthermore, we derive equilibria under the two scenarios and the existence and proved the existence and the uniqueness of the equilibria. The results show that the intention plays an important role in decision making of the supply chain and will significantly change the equilibria. Moreover, an acrimonious channel can be coordinated with a simple wholesale-price contract under certain conditions, which can never happen in a traditional

*This chapter is primarily referenced from: Shaofu Du, **Tengfei Nie**, Chengbin Chu, and Yugang Yu (2014). Reciprocal supply chain considering intention impact. European Journal of Operational Research, 239(2): 389-402. DOI: 10.1016/j.ejor.2014.05.032.

channel. A harmonious channel, however, cannot be coordinated in any way.

4.1 Introduction

With the development of behavioral economics, there are more and more doubts regarding the traditional assumption of *rationality*. Many experiments show that the decision-maker considers not only the profits but also other behavioral factors such as fairness. Investigations of an ultimatum game demonstrated that both the proposer and the responder have a strong preference on fairness and thus leads to unique results which deviate significantly from traditional theoretical predictions. Our research is based on a two-echelon supply chain system composed of one single supplier and one single retailer, who conduct a Stackelberg game, where the supplier acts as the leader and the retailer acts as the follower. How to make optimal price is the key question for both parties. According to Cachon (2003), this kind of model is not complex, but it is sufficiently rich to study important questions in supply chain coordination. After incorporating behavioral factors, we are going to build a model in which both the supplier and the retailer are concerned with fairness and will evaluate the kindness of an action not only by its consequence but also by its underlying intention.

In the context of supply chain, fairness is always a hot issue. However, traditional theories neglect this aspect and often assume that decision-makers will maximize their own profits as much as they can. Actually, many other important factors should be considered to derive a conclusion which is consistent with the reality. In the ultimatum game, the proposal which is very unfavorable to the responder won't be provided because the proposer knows that both of them are fairness concerned. He is destined to suffer retaliation and two parties get nothing if he appears to be so greedy. In real world, impacts of the behavioral factors cannot be ignored as long as the decisions involve game. Most studies on fairness are based on behavioral experiments. On the basis of these experiments, all kinds of behavioral models are proposed. They can be divided into two major types: the first one is called equity-based model and it is mainly judged by the consequence of an action; the second type is called reciprocity model, which takes people's intentions into account as well. We refer to Korth (2009) for comprehensive review.

At the practical level, reciprocity is also an important issue because many relevant decisions are likely to be affected if the attribution of intentions matters. For example, political decisions and business decisions often affect some parties' material payoffs negatively. It will be much easier to prevent opposition if the decision-maker can demonstrate that he is somehow forced by law, international competition and some other external forces to take that action if the response of the negatively affected parties also takes into account the decision-maker's intentions (Falk et al., 2008). Another example, a hardware store is considered unkind to raise the price during a blizzard because it takes advantage of the short-run increase in demand, while the similar action of a grocer is more acceptable because the wholesale price has increased due to a transportation mixup (Kahneman et al., 1986b). The reason is that the latter has the need to protect normal profit while the former loots a burning house. In addition, you may buy a product from a convenience store with a low price; however, it is also acceptable when the same product is sold with a high price in a big mall since you know that they have different costs. The attribution of intentions is also important in law (Huang, 2000). Intentions often distinguish between whether the same action is a tort or a crime and whether an action is purposely taken. Thus, the penal code distinguishes quite carefully between the consequences of an action and its underlying intentions. Furthermore, a consumer may not buy a product sold by a monopolist at an "unfair" price, even though the consumer can get greater material value than the price from buying it, because he believes that the monopolist is unkind with obvious intention. Thus, he wants to punish the monopolist by not buying, even if at the cost of lowering his own material well-being (Rabin, 1993). The study of Blinder and Choi (1990) suggests that employers are unwilling to lower wagers when there is a unemployment, because the owner believes that wage level may positively affects workers' propensity to cooperate since it indicates the underlying intention, especially in the presence of unemployment.

This research first analyzes the channel in which only the retailer has a preference for reciprocity while the supplier merely seeks to maximize her profit. After that, we extend our study to the case where both members have reciprocal preferences. In this chapter, we refer to a channel with single or multi reciprocity-preferred members as a *reciprocal channel*. Our study shows that no matter whether the supplier has a preference for reciprocity or not, the channel can be coordinated with a wholesale-price contract as long as the retailer has such a social preference in acrimonious supply chains ($\gamma\mu > 1$, where γ and μ are the fairness parameters of the retailer and the supplier respectively and we provide detailed explanation of them thereafter). However, it seems strange that it should have failed to coordinate the harmonious supply chain ($\gamma\mu \leqslant 1$). Furthermore, some counter-intuitive phenomena may appear. In the acrimonious supply chain, the retailer may charge a price which is lower than the optimal retail price of traditional channel when the supplier's wholesale price is relatively high and the retail price may decrease with the wholesale price.

The rest of this chapter is organized as followed. In Section 4.2, the psychological game model of considering intention within a supply chain context is given. In Section 4.3, we analyze the model in detail and derive the equilibria under different scenarios. The impacts of some important parameters on the equilibrium were presented in Section 4.4. Section 4.5 summarizes our conclusions.

4.2 The Model

This chapter considers the standard dyadic channel consisting of a single supplier and a single retailer. The supplier and the retailer play a classical Stackelberg game. The supplier moves first and charges a constant wholesale price w (per unit product). Then, the retailer sets his retailer price p (per unit product). For simplicity, we assume that only the supplier incurs a unit production cost c in this channel. The market demand $D(p)$ is assumed to be a decreasing function of retailer price p, mathematically, $D(p) = a - bp$, where a, b are positive constants. $0 < p \leqslant \frac{a}{b}$ is necessary to ensure that the demand is not negative. Then, the two members' profit functions can be written as follows.

The supplier's profit function:

$$\pi_s = (w - c)D(p) \tag{4.1}$$

The retailer's profit function:

$$\pi_r = (p - w)D(p) \tag{4.2}$$

The whole channel's profit function is given by $\pi = (p - c)D(p)$, and the retail price of integrated channel is $p_c = \frac{a+bc}{2b}$.

We assume that both the supplier and the retailer have similar mental characteristics. For example, the retailer has a reference point of fairness in his mind, if the profits that he gains doesn't reach this point, he is likely to analyze the supplier's intention to see if he deliberately makes this decision or he has some difficulties that he is reluctant to mention. If the retailer concludes that the supplier is being unkind to him, he will punish the supplier by increasing the retail price, because this will reduce market demand and thus may be harmful to the supplier's brand. Of course, it may also cause trouble to the retailer himself. However, if the decision that the supplier made is the best thing he could do for the retailer, the penalty reduces. The supplier also has this characteristic of reciprocity.

In the supply chain, it is the optimal choice for the supplier and the retailer to maximize their profits if no other possible factors involved. However, Many behavioral factors which were ignored by traditional theory of economics are vital for making decision. For example, the reputation of the player is very important to guarantee long term relationship of corporation. Even though it is a "once-for-all" deal, it is not rational for the retailer (supplier) to concentrate on his own profits solely, because he may obtain less profits or even get nothing (e.g. ultimatum game) by taking self-centered policy when the other party concerns about fairness, even if it is costly to him.

In our model, we assume that the two members have the same preference: if the supplier is perceived kindness by the retailer, the retailer will reciprocate him even the consequence is not so good to the retailer; otherwise, the supplier will be punished even the retailer may pay the price of losing profits. This is what we mean by reciprocity. Therefore, when will one member rewards or punishes the other depends on the prediction of his kindness or unkindness instead of solely rely on the consequence. That is the biggest difference between fairness model and reciprocity model. The reciprocity model will consider the consequence of one action or decision of the other and its intention hidden behind. Moreover, its intention is more important than the consequence. Here, we can not neglect the consequence and only emphasize the role of intention. When the retailer predict that he will get little profits due to the supplier's decision, he will take some credible threatening measures to prevent the supplier from doing so before the game starts, or we can say that the supplier will try to avoid leaving little profits to the retailer.

In addition, both members know the other's strategy space, payoffs and the benchmark of fairness. This benchmark is not necessarily a point; it is more likely an interval. If an action taken by the supplier results in profits of the retailer far from his benchmark of fairness, the supplier will be considered as being intentional and suffers punishment from the retailer. In the working paper of Falk and Fischbacher (2006), two ultimatum games were compared to demonstrate the importance of intention. Under the background of supply chain, the strategy spaces of two members are continuous and thus are different from that of the ultimatum game. Neither of the decision-makers can easily find out whether the opponent is kind to him or not, since the boundary is not very clear. That is what we want to expound in the following parts.

Both the supplier and the retailer have their own benchmark of fairness in their minds, which can be used to evaluate the kindness of the other party. We assume that the equitable payoff of the retailer π_{rfb} is γ times the supplier's outcome, i.e., $\pi_{rfb} = \gamma(w-c)D(p)$. Likewise, the equitable payoff of the supplier π_{sfb} is μ times that of the retailer's outcome, i.e., $\pi_{sfb} = \mu(p-w)D(p)$. This way of describing equitable payoff can also be found in the literature on distributive fairness (see Macneil, 1980; Frazier, 1983; Cui et al., 2007). Here, γ and μ are both assumed to be positive and are exogenous variables in our model.

We first write out the utility functions of the supplier and the retailer as follows. Here, we use inherit a structure similar to the model of Falk and Fischbacher (2006).

The supplier's utility function:

$$U_s = \pi_s + \rho_s \theta_r \Delta_r \sigma_s \tag{4.3}$$

The retailer's utility function:

$$U_r = \pi_r + \rho_r \theta_s \Delta_s \sigma_r \tag{4.4}$$

Now we will explain each term of the utility functions. Because the two utility functions are symmetrical to each other, we use the retailer's utility function for the example. The utility function consists of two parts. The first part; i.e., the profits term, has been extensively addressed in classical models. We therefore focus on the second part; i.e., the reciprocity utility term. The reciprocation utility term is the product of four parameters: they are ρ_r, θ_s, Δ_s and σ_r. ρ_r is the *reciprocity parameter*, which captures the retailer's degree of reciprocal concern and $\rho_r > 0$. It can be regarded as a weight endowed to the utility by rewarding kindness or by punishing unkindness. The larger ρ_r, the more attention the retailer pays to reciprocate the supplier. If $\rho_r = 0$, it degenerates to traditional condition, which means that the retailer is not concerned about reciprocation, and maximizing profits is the only objective he pursues. $\theta_s \in (0,1]$ is called *intention factor* which represents the degree of confidence or certainty of the retailer about the supplier's intention of kindness or unkindness, and $0 < \theta_s \leqslant 1$. If the retailer is sure enough that the supplier is kind or unkind to him, $\theta_s = 1$; $0 < \theta_s < 1$ [1]means the retailer is not completely sure whether the supplier is kind or unkind. *Outcome term* Δ_s can be used to show the kindness

[1]In this chapter, $\theta_s = \xi_r$ or $\theta_r = \xi_s$ indicate that the retailer or the supplier is not sure whether his copartner is kind or unkind, where ξ_r and ξ_s are the default values of intention factors of the retailer and the supplier, respectively. The greater the ξ_r (ξ_s) is, the more confidence the retailer (supplier) knows the other party's intention. However, 0 and ξ_r (ξ_s) have essential difference in describing the degree of intention. The same essential difference exists between ξ_r (ξ_s) and 1.

or unkindness of the supplier to the retailer after taking one action. *Reciprocation term* σ_r represents the retailer's reward for kindness or punishment for unkindness. ρ_r, ρ_s, ξ_r and ξ_s are all exogenous parameters.

We are going to build a psychological game model; therefore, it is necessary to introduce some parameters which are related to belief. Let p' denote the first-order belief of the supplier. It captures the supplier's belief about the retail price that the retailer will apply. As a consequence, it is one of the elements of the strategy of the supplier. This element is used to determine the supplier's behavior since she does not know the strategy with certainty. As p' is an element of the strategy of the supplier, the retailer does not know its value, therefore, he has to "guess" it. This "guess" is represented by p'', the second-order belief of the retailer, which captures the retailer's belief about what the supplier believes about the retail price he will apply. As a result, p'' is one of the elements of the strategy of the retailer. In a similar way, we can define the first-order belief of the retailer, denoted by w', and the second-order belief of the supplier denoted as w''.

In the following section, we will show how to judge the intention factor for each decision-maker. In games such as ultimatum game, it is reasonable to regard "half pie" as the benchmark of fairness. However, this benchmark of fairness is not suitable for many practical business dealings. If we apply this benchmark to the background of supply chain, it means that the retailer and the supplier are supposed to get the same profits. Obviously, this is not in line with the reality. Under our hypothesis, the way of judging kindness or unkindness is not only by comparing one's own profits with his partner's or with his own expected profits, but also the relationship with the reason why he chooses this strategy instead of other optional strategies, and thus the underlying intention of an action may be prominent. We will explain it mathematically in more detail below.

Falk and Fischbacher (2006) summarized a series of rules to measure intention factor from the results of a questionnaire. Most of them are reasonable and intuitive to some extent whereas some flaws are inevitable. In their opinion, only if player A chooses a strategy while he has other strategies to reduce player B's payoff, can player B ensure that player A is definitely kind to him, which implies that the intention factor of player B equals 1. This rule was used to evaluate the intention factor of the employer to the employee in the gift exchange game. Based on this rule, it is not difficult to deduce that the employer is kind to the employee as long as he offers a wage which is more than zero. However, there are many counterexamples to show that this deduction is unlikely to be the truth. For example, it will definitely be deemed as unkind and thus be refused if a firm offers a job seeker 500 Chinese Yuan per month while the average monthly wage of a common employee of this firm is about 2000-3000 Chinese Yuan. The problem lies in that it ignores the average level of salary. Therefore, the conclusions derived by analyzing an ultimatum game can be rarely applied in practice. Consequently, the average level of salary is included as a constraint condition in our model. Moreover, there is another important flaw in the ultimatum game. A small supplier is not expected to get the same profits as a large retailer since they are unequal in scale, strength, contribution and so on. We thus relax the assumption of fairness benchmark in our model. Accordingly, the intention factor θ_s can be expressed by the following mathematical expression which we will explain in detail in the next part (θ_r has similar expression and explanation).

$$\theta_s = \begin{cases} \left.\begin{array}{l} 1, \exists \tilde{w} \quad \pi_r(\tilde{w}, p'') < \pi_r(w, p'') \\ and \quad \pi_s(\tilde{w}, p'') \geqslant \mu \pi_r(\tilde{w}, p'') \\ \xi_r, otherwise \end{array}\right\} if \quad \pi_r(w, p'') \geqslant \gamma \pi_s(w, p'') \\ \left.\begin{array}{l} 1, \exists \tilde{w} \quad \pi_r(\tilde{w}, p'') > \pi_r(w, p'') \\ and \quad \pi_s(\tilde{w}, p'') \geqslant \mu \pi_r(\tilde{w}, p'') \\ \xi_r, otherwise \end{array}\right\} if \quad \pi_r(w, p'') < \gamma \pi_s(w, p'') \end{cases} \tag{4.5}$$

4.2.1 Intention Factor

The retailer has this mental activity in his mind after the supplier makes a decision: first, he wonders if the profit he obtains (we call it Level A for short) from the supplier's action can achieve or even exceed his fairness benchmark by comparing $\pi_r(w, p'')$ and $\gamma\pi_s(w, p'')$. Then, the retailer will test if there are any strategies that the supplier can take in her strategy sets to let the retailer get more profits than Level A. If there are, the retailer may have reason to believe that the supplier is unkind to him since she has other choices to make the retailer better off. He knows this by comparing $\pi_r(\tilde{w}, p'')$ and $\pi_r(w, p'')$. The comparison between $\pi_s(\tilde{w}, p'')$ and $\mu\pi_r(\tilde{w}, p'')$ in θ_s is used by the retailer to find out the reason why the supplier does not choose other alternatives. Therefore, the retailer will be certain about whether the supplier is kind to him and its degree (which is reflected by intention factor θ_s) by combining the above. In order to make it clear and figure out how these conditions work in θ_s, we explain them in detail as follows.

There are four possible circumstances for intention factor θ_s under different combinations of three conditions. In the first circumstance, the retailer can ensure that the supplier is kind to him, thus $\theta_s = 1$ if (1) the supplier chooses strategy w [2] which brings a profit of more than his reference level (or fairness benchmark) for the retailer ($\pi_r(w, p'') \geqslant \gamma\pi_s(w, p'')$); (2) in the supplier's strategy sets, if there is a strategy $\tilde{w}$ which can bring lower profits for the retailer ($\pi_r(w, p'') > \pi_r(\tilde{w}, p'')$) but she does not choose it and, (3) the supplier has the chance to obtain profits more than her fairness benchmark by selecting the strategy $\tilde{w}$ ($\pi_s(\tilde{w}, p'') > \mu\pi_r(\tilde{w}, p'')$). The reason this matters is because the supplier has at least one strategy to reduce the retailer's payoff and at the same time, it will also achieve her fairness benchmark, however, the supplier gives up this strategy. This obviously shows that the supplier is kind to the retailer and the retailer will perceive her kindness.

The second circumstance of θ_s is a complement set of the first circumstance under the same precondition. At this moment, the retailer cannot be sure if the supplier is faithfully kind to him. If the supplier doesn't choose another strategy, it is probably because that strategy is not good for her (which means it may reduce her profits) instead of being considerate of the retailer. In any event, however, she doesn't destroy the retailer's advantage. Therefore, the supplier is also assumed to be kind to the retailer when her intention of kindness is inconspicuous, i.e., $\theta_s = \xi_r$.

In the third circumstance, optional strategy $\tilde{w}$ will increase the retailer's profits ($\pi_r(w, p'') < \pi_r(\tilde{w}, p'')$) while simultaneously the supplier's profits will be more than her fairness benchmark ($\pi_s(\tilde{w}, p'') > \mu\pi_r(\tilde{w}, p'')$), but she discards this strategy, and what is more, the retailer fails to get fair profits ($\pi_r(w, p'') < \gamma\pi_s(w, p'')$). Consequently, the supplier is assumed to be definitely unkind to the retailer. The retailer perceives this unkindness of the supplier very clearly and the intention factor can be expressed by $\theta_s = 1$.

Similarly, the fourth circumstance is also a complement set of the third circumstance under the precondition of ($\pi_r(w, p'') < \gamma\pi_s(w, p'')$). After the supplier chooses the strategy w, the retailer cannot achieve his fairness benchmark, so normally he would believe that the supplier is unkind to him. However, other conditions cannot provide enough evidence for the retailer to believe that the supplier is intending to do that, because there is a possibility that the supplier's intention is just self-protection. It is this reason that reduces the significance of unkindness from the supplier perceived by the retailer, thus, $\theta_s = \xi_r$ is used to express this ambiguous

[2] It means that the wholesale price charged by the supplier is w and it is the same meaning for strategy $\tilde{w}$. However, the precise meaning of $\tilde{w}$ is all strategies except strategy w.

unkindness. Next, based on Eq. (4.5), we will provide directly the intervals of θ_s that can satisfy the conditions in four circumstances respectively.

If $\pi_r(w,p'') \geqslant \gamma\pi_s(w,p'')$, which means $p'' \geqslant (\gamma+1)w-\gamma c$, we have $\theta_s = 1$ if simultaneously $\{\tilde{w}\,|\,\pi_r(\tilde{w}\,,p'') < \pi_r(w\,,p'')\} \cap \{\tilde{w}\,|\,\pi_s(\tilde{w}\,,p'') \geqslant \mu\,\pi_r(\tilde{w}\,,p'')\} \neq \emptyset$. In addition, we have $\{\tilde{w}\,|\pi_s(\tilde{w},p'') \geqslant \mu\pi_r(\tilde{w},p'')\} = \left\{\tilde{w}\,\middle|\,\frac{\mu p''+c}{\mu+1} \leqslant \tilde{w} < p''\right\}$ and $\{\tilde{w}|\pi_r(\tilde{w},p'') < \pi_r(w,p'')\} = \{\tilde{w}|w < \tilde{w} < p''\}$, then

$$
\begin{aligned}
&\{\tilde{w}\,|\pi_r(\tilde{w},p'') < \pi_r(w,p'')\} \cap \{\tilde{w}\,|\pi_s(\tilde{w},p'') \geqslant \mu\pi_r(\tilde{w},p'')\} \\
&= \left\{\tilde{w}\,\middle|\max\left(w, \frac{\mu p''+c}{\mu+1}\right) \leqslant \tilde{w} < p''\right\} \neq \emptyset
\end{aligned}
$$

If $\pi_r(w,p'') < \gamma\pi_s(w,p'')$, which means $p'' < (\gamma+1)w-\gamma c$, we have $\theta_s = 1$ if simultaneously $\{\tilde{w}\,|\,\pi_r(\tilde{w}\,,p'') > \pi_r(w\,,p'')\} \cap \{\tilde{w}\,|\,\pi_s(\tilde{w}\,,p'') \geqslant \mu\,\pi_r(\tilde{w}\,,p'')\} \neq \emptyset$. In fact,

$$
\begin{aligned}
&\{\tilde{w}\,|\pi_r(\tilde{w},p'') > \pi_r(w,p'')\} \cap \{\tilde{w}\,|\pi_s(\tilde{w},p'') \geqslant \mu\pi_r(\tilde{w},p'')\} \\
&= \{\tilde{w}\,|c < \tilde{w} < w\} \cap \left\{\tilde{w}\,\middle|\,\frac{\mu p''+c}{\mu+1} \leqslant \tilde{w} < p''\right\}
\end{aligned}
$$

Therefore, we have following possible cases.

(1) *unambiguous kindness* (i.e., $\theta_s = 1$). According to our assumption, $p'' \geqslant (\gamma+1)w-\gamma c$ tells us that the supplier is kind to the retailer. Because $\frac{\mu p''+c}{\mu+1} < p''$, $\{\tilde{w}\,|\,p'' > \tilde{w} > w\} \cap \{\tilde{w}\,|\,p'' > \tilde{w} \geqslant \frac{\mu p''+c}{\mu+1}\} \neq \emptyset$ always holds, which means that the retailer believes the supplier is kind to him from the bottom of her heart. Thus, the constraint condition for this case is $p'' \geqslant (\gamma+1)w-\gamma c$.

(2) *unambiguous unkindness* (i.e., $\theta_s = 1$). $p'' < (\gamma+1)w-\gamma c$ indicates that the retailer perceives unkindness from the supplier. $\{\tilde{w}\,|\,\tilde{w} < w\} \cap \{\tilde{w}\,|\,p'' > \tilde{w} \geqslant \frac{\mu p''+c}{\mu+1}\} \neq \emptyset$ when $p'' < \frac{(\mu+1)w-c}{\mu}$. Therefore, $p'' < (\gamma+1)w-\gamma c$ and $p'' < \frac{(\mu+1)w-c}{\mu}$ are the constraints for this case.

(3) *ambiguous unkindness* (i.e., $\theta_s = \xi_r$). Likewise, $p'' < (\gamma+1)w-\gamma c$ is the premise. When $w < \frac{\mu p''+c}{\mu+1}$, i.e., $p'' > \frac{(\mu+1)w-c}{\mu}$, $\{\tilde{w}\,|\,\tilde{w} < w\} \cap \{\tilde{w}\,|\,p'' > \tilde{w} \geqslant \frac{\mu p''+c}{\mu+1} = \emptyset$, which shows that the unkindness perceived by the retailer is ambiguous.

(4) *ambiguous kindness* (i.e., $\theta_s = \xi_r$). This case does not exist since $\{\tilde{w}\,|\,p'' > \tilde{w} > w\} \cap \{\tilde{w}\,|\,p'' > \tilde{w} \geqslant \frac{\mu p''+c}{\mu+1}\} \neq \emptyset$ always holds when $\frac{\mu p''+c}{\mu+1} < p''$.

Consequently, we can conclude the constraints for the above cases by comparing $(\gamma+1)w-\gamma c$ with $\frac{(\mu+1)w-c}{\mu}$ as follows.

When $(\gamma+1)w-\gamma c > \frac{(\mu+1)w-c}{\mu}$, i.e., $\gamma\mu > 1$:

(i) $p'' \geqslant (\gamma+1)w-\gamma c$ is the constraint for *unambiguous kindness*;

(ii) $p'' < \frac{(\mu+1)w-c}{\mu}$ is the constraint for *unambiguous unkindness*;

(iii) $\frac{(\mu+1)w-c}{\mu} \leqslant p'' < (\gamma+1)w - \gamma c$ is the constraint for *ambiguous unkindness*.

When $(\gamma+1)w - \gamma c \leqslant \frac{(\mu+1)w-c}{\mu}$, i.e., $\gamma\mu \leqslant 1$:

(i) $p'' \geqslant (\gamma+1)w - \gamma c$ is the constraint for *unambiguous kindness*;

(ii) $p'' < (\gamma+1)w - \gamma c$ is the constraint for *unambiguous unkindness*;

(iii) The case of *ambiguous unkindness* does not exist under this condition.

Simultaneously, it is worth noticing that $\mu\pi_r$, i.e., $\left[\frac{\mu}{1+\mu}\right]\pi_{TSC}$, is the reference point of profits for the supplier; and $\gamma\pi_s$, i.e., $\left[\frac{\gamma}{1+\gamma}\right]\pi_{TSC}$, is the reference point of profits for the retailer. The sum of the two reference points is $\left[\frac{\gamma}{1+\gamma}+\frac{\mu}{1+\mu}\right]\pi_{TSC}$, which can be called the equity-capable channel payoff (ECCP). We inherit the definitions of the two kinds of channels ($\gamma\mu > 1$ and $\gamma\mu \leqslant 1$) from Cui et al. (2007). That is, we call it a harmonious supply chain when $\gamma\mu \leqslant 1$ since "an equitable division of channel profits is feasible"; when $\gamma\mu > 1$, we call it an acrimonious supply chain since "the two channels members jointly desire more monetary payoffs than what the channel is capable of producing".

To sum up, according to above discussion and classification, we have two kinds of supply chains, harmonious supply chains and acrimonious supply chains. In a harmonious supply chain, there is only one possibility, i.e., the intention is unambiguous (RH1), and the constraint is $w < p'' < \frac{a}{b}$. For an acrimonious supply chain, there are two possibilities: the intentions are unambiguous (RC1) and ambiguous respectively (RC2). The constraints for RC1 are $w < p'' < \frac{(\mu+1)w-c}{\mu}$ or $(\gamma+1)w - \gamma c \leqslant p''$. $\frac{(\mu+1)w-c}{\mu} \leqslant p'' < (\gamma+1)w - \gamma c$ is the constraint for RC2.

4.2.2 Outcome Term

Define $\Delta_i, i \in \{r,s\}$ as the outcome term, which captures the kindness of player i as perceived by his partner $j, j \in \{r,s\}, j \neq i$. The outcome term is formulated as the difference between the profits j obtains and his fairness benchmark after i takes an action or uses a strategy. If i is perceived as kind, the bigger the difference, the more reward he gets; if i is perceived as unkind, he will be punished more by j as the difference becomes larger. The player j infers whether i is kind or unkind to him by the outcome term; based on the intention factor, he decides the degree of reward or punishment.

Mathematical expressions for Δ_r and Δ_s are:

$$\Delta_r = \pi_s(w'', p') - \mu \pi_r(w'', p') \tag{4.6}$$

$$\Delta_s = \pi_r(w, p'') - \gamma \pi_s(w, p'') \tag{4.7}$$

We can see that Eq. (4.6) and Eq. (4.7) are not symmetrical. In Eq. (4.7), w is used instead of w'. This is because the supplier moves first. When the retailer tries to determine the kindness or unkindness of the supplier (by computing Δ_s), he knows the wholesale price chosen by the supplier, i.e., w. In contrast, the supplier does not know the strategy chosen by the retailer when she determines his kindness or unkindness. She has to "guess" it, and therefore, she uses p' to compute Δ_r.

4.2.3 Reciprocation Term

In the next step, the second mover will take an action to reciprocate the first mover according to his perception about her intention. The process can be expressed by a reciprocation term. In particular, we have

$$\sigma_r = \pi_s(w, p) - \pi_s(w, p'') \tag{4.8}$$

$$\sigma_s = \pi_r(w, p') - \pi_r(w'', p') \tag{4.9}$$

In our model, σ_r means that the retailer takes an action to affect the payoff of the supplier and σ_s indicates that the supplier adopts a strategy to influence the retailer's profits. To be specific, σ_r shows the following decision process: after the supplier takes strategy w, her expected profit is $\pi_s(w, p')$, which becomes $\pi_s(w, p'')$ when seen from the perspective of the retailer. According to the results indicated by intention factor and outcome term, the retailer uses strategy p and the supplier's profits becomes $\pi_s(w, p)$. The gap between $\pi_s(w, p)$ and $\pi_s(w, p'')$ is σ_r. If σ_r is positive, it means the retailer believes the strategy w taken by the supplier is a good or fair wholesale price and thus the retailer rewards the supplier and she gets a profit more than her expected level. $\sigma_r < 0$ expresses the opposite meaning.

There is a difference between σ_s and σ_r. After the retailer adopts strategy p' [3], the supplier

[3]In the context of a dyadic channel, the supplier and the retailer play a Stackelberg game, the supplier is the leader and moves first, the retailer is the follower and moves second, thus, there may be a doubt on strategy p': why could the retailer execute strategy p' before the supplier taking an action since he is the second mover? In fact, p' is not the real strategy, it is merely a belief that the supplier believes what retail price the retailer will charge.

perceives his attitude, kindness or unkindness, and then try to speculate on his intention. In the retailer's mind, the profit he hopes to get is $\pi_r(w, p'')$, which becomes $\pi_r(w'', p')$ when we see it through the eyes of the supplier. Then the retailer's profit becomes $\pi_r(w, p')$ after the supplier adopts strategy w. Likewise, the difference between $\pi_r(w, p')$ and $\pi_r(w'', p')$ is σ_s. $\sigma_s > 0$ and $\sigma_s < 0$ denote the supplier's reward for kindness and punishment to unkindness respectively.

4.2.4 Reciprocation Utility Term

In the utility function, the reciprocation utility term [4] is used to represent the utility that is derived from rewarding or punishing his partner. For example, if the supplier is perceived as kind, i.e., $\pi_r(w, p'') > \gamma\pi_s(w, p'')$, she will be rewarded by the retailer, i.e., $\pi_s(w, p) > \pi_s(w, p'')$. The production of Δ_s and σ_r is positive, which means it will increase the retailer's second utility by rewarding the supplier's kindness (ρ_r and θ_s are positive parameters). However, the retailer's utility will also increase when he takes a strategy to punish the supplier's unkindness since we have $\pi_r(w, p'') < \gamma\pi_s(w, p'')$ and $\pi_s(w, p) < \pi_s(w, p'')$ at this moment. Said differently, no matter whether the supplier is perceived as kind or unkind, the retailer's second utility will increase if he takes a reasonable action to reciprocate her.

4.3 Model Analysis

In our model, the supplier and the retailer play a Stackelberg-like game. The first mover is the supplier, who offers a wholesale price w to maximize her utility, and then the retailer as a responder decides to accept or reject it. If he rejects, the game is over and payoffs are zero for both members. If he accepts the wholesale price, he makes a decision about the retail price p by optimizing his utility. We incorporate reciprocity into this traditional game to investigate how the fairness and intention factors affect the members' decisions and channel's coordination. This supply chain is called a reciprocal supply chain. With this background, once the wholesale price is given, the retailer needs to evaluate the supplier's kindness and intention so as to charge a reasonable retail price. Said differently, the retailer has the ability to reciprocate the supplier's action by way of changing the retail price. As for the supplier, however, how does she evaluate the retailer's intention since she is the first mover? Here, we have to introduce the psychological

[4] We have to emphasize that the reciprocation utility term is different from the reciprocation term. The reciprocation utility term is the second part of the decision-maker's utility function and it is used to reflect the change in the utility level because of reciprocation; it is a product of four terms, including the reciprocation term.

game to solve this problem. The supplier and the retailer make decisions based on their own beliefs, which we have explained in detail in previous parts and will be expounded in the process of model analysis.

In a psychological game, the Psychological Nash Equilibrium is the counterpart of the Nash Equilibrium in game theory. The difference lies in the fact that the decision-maker's utility depends not only on the strategy chosen by other players, but also on belief. Nevertheless the beliefs are not a part of the strategy space, which means the players can not change the payoff by their beliefs. Compared with traditional Nash Equilibrium, Psychological Nash Equilibrium requires that beliefs are equal to actual behaviors. Therefore, in the state of equilibrium, we have $p = p' = p''$, $w = w' = w''$. This assumption is reasonable, especially for the game in which players are familiar with each other (within a supply chain, the supplier deals with the retailer frequently and they often know each other well) and it is consistent with the past literature on psychological games (see Geanakoplos et al., 1989). According to the method of backward inference, we consider the decision of the second mover- the retailer first.

4.3.1 The Reciprocal Retailer's Decision

As we can see from previous analysis, the most important thing for analyzing the decision of the retailer (supplier) is to decide the intention factor perceived by the supplier (the retailer). This was discussed in the previous section and can be reduced to a relatively simple expression. However, with different $\gamma\mu$, the value of θ_s is different. According to previous analysis, we should discuss the decision problem under two kinds of supply chain.

1. **Harmonious Supply Chain** ($\gamma\mu \leqslant 1$)

(RH1). Unambiguous Kindness. The retailer's optimization problem [5]is given by

$$\max_{p} \ (p-w)(a-bp)+\rho_r(a-bp'')(w-c)b\left[p''-((\gamma+1)w-\gamma c)\right](p''-p) \tag{4.10}$$

$$s.t. \quad w < p < \frac{a}{b} \tag{4.11}$$

[5]In fact, the constraint of Eq. (4.11) is $w < p'' < \frac{a}{b}$. However, according to psychological game theory, $p'' = p$ only if the game achieves equilibrium, so $w < p < \frac{a}{b}$ can be used to replace $w < p'' < \frac{a}{b}$. The same reasoning applies for the constraints of RC1 and RC2.

The retailer's optimal price is given by

$$p_{h_1} = p^- \tag{4.12}$$

where

$$p^- = \frac{\left\{ \begin{array}{l} \rho_r(w-c)\left[a+b((1+\gamma)w-\gamma c)\right]+2 \\ -\sqrt{(\rho_r)^2(w-c)^2(a-b((1+\gamma)w-\gamma c))^2+4b\gamma\rho_r(w-c)^2+4} \end{array} \right\}}{2b\rho_r(w-c)}$$

Proof. See Appendix B.1.1. □

2. **Acrimonious Supply Chain** ($\gamma\mu > 1$)

(RC1). Unambiguous Kindness. The retailer's optimization problem is given by

$$\max_p \ (p-w)(a-bp)+\rho_r(a-bp'')(w-c)b\left[p''-((\gamma+1)w-\gamma c)\right](p''-p) \tag{4.13}$$

$$s.t. \quad w < p < \frac{(\mu+1)w-c}{\mu} \ or \ (\gamma+1)w-\gamma c \leqslant p \tag{4.14}$$

The optimal retail price of the retailer is

$$p_{c_1} = \begin{cases} p^-, c < w < \frac{a+2b\gamma c}{b(2\gamma+1)} \ or \ w_{\rho_r} \leqslant w < \frac{a}{b} \\ (\gamma+1)w-\gamma c, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \\ \frac{(\mu+1)w-c}{\mu}, \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \leqslant w < w_{\rho_r} \end{cases} \tag{4.15}$$

where w_{ρ_r} is the unique real root of equation $f_{\rho_r}(w) = 0$.

$$\begin{aligned} f_{\rho_r}(w) = \rho_r(w-c)^2\left\{\mu(a-bw)-b(w-c)\right\}b(\gamma\mu-1) \\ -\mu\left[2b(w-c)-\mu(a-bw)\right] \end{aligned}$$

Proof. See Appendix B.1.2. □

(RC2). Ambiguous Unkindness. The retailer's optimization problem is given by

$$\max_p \ (p-w)(a-bp)+\rho_r\xi_r(a-bp'')(w-c)b\left[p''-((\gamma+1)w-\gamma c)\right](p''-p) \tag{4.16}$$

$$s.t. \quad \frac{(\mu+1)w-c}{\mu} \leqslant p < (\gamma+1)w-\gamma c \tag{4.17}$$

The optimal retail price for the retailer is

$$p_{c_2} = \begin{cases} (\gamma+1)w-\gamma c,\, c < w < \frac{a+2b\gamma c}{b(2\gamma+1)} \\ p^-_{\xi_r},\, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < w_{\rho\xi r} \\ \frac{(\mu+1)w-c}{\mu},\, w_{\rho\xi r} \leqslant w < \frac{a\mu+bc}{b(\mu+1)} \\ \frac{a}{b},\, \frac{a\mu+bc}{b(\mu+1)} \leqslant w < \frac{a}{b} \end{cases} \tag{4.18}$$

where $w_{\rho\xi r}$ is the real root of equation $f_{\rho\xi r}(w) = 0$.

$$\begin{aligned} f_{\rho\xi r}(w) = {} & \rho_r\xi_r(w-c)^2\{\mu(a-bw)-b(w-c)\}b(\gamma\mu-1) \\ & -\mu[2b(w-c)-\mu(a-bw)] \end{aligned}$$

$$p^-_{\xi_r} = \frac{\left\{ \begin{array}{l} \rho_r\xi_r(w-c)[a+b((1+\gamma)w-\gamma c)]+2 \\ -\sqrt{(\rho_r\xi_r)^2(w-c)^2(a-b((1+\gamma)w-\gamma c))^2+4b\gamma\rho_r\xi_r(w-c)^2+4} \end{array} \right\}}{2b\rho_r\xi_r(w-c)}$$

Proof. See Appendix B.1.3. □

For the acrimonious supply chain ($\gamma\mu > 1$), we have two scenarios: RC1 and RC2. The retailer will choose a way to maximize his utility by combining RC1 and RC2 and making a comparison between them. Specifically, for a wholesale price w, the retailer has two possible optimal responsive retail prices, one is in RC1 and the other is in RC2, and he only needs to choose one to maximize his utility. Getting his optimal retail price requires $p = p''$. Therefore, the utility based on which the retailer choose his optimal retail price is $U_r = (p-w)(a-bp)$.

We can easily prove that $w_{\rho\xi_r} < w_{\rho_r}$. Therefore, we obtain $c < \frac{a+2b\gamma c}{b(2\gamma+1)} < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} < w_{\rho\xi_r} < w_{\rho_r} < \frac{a\mu+bc}{b(\mu+1)} < \frac{a}{b}$. Furthermore, it is not difficult to derive six equivalent relationships as follows.

$$\begin{cases} p^- \leqslant \frac{a+bw}{2b} \Leftrightarrow c < w \leqslant \frac{a+2b\gamma c}{b(2\gamma+1)} \\ p^-_{\xi_r} \leqslant \frac{a+bw}{2b} \Leftrightarrow c < w \leqslant \frac{a+2b\gamma c}{b(2\gamma+1)} \\ \frac{(\mu+1)w-c}{\mu} \leqslant \frac{a+bw}{2b} \Leftrightarrow c < w \leqslant \frac{a\mu+2bc}{b(\mu+2)} \\ (\gamma+1)w-\gamma c \leqslant \frac{a+bw}{2b} \Leftrightarrow c < w \leqslant \frac{a+2b\gamma c}{b(2\gamma+1)} \\ f_{\rho r}\left(\frac{a\mu+2bc}{b(\mu+2)}\right) = \frac{(a-bc)^3\mu^3(\gamma\mu-1)\rho_r}{b(2+\mu)^3} > 0 \Leftrightarrow \frac{a\mu+2bc}{b(\mu+2)} < w_{\rho r} \\ f_{\rho\xi r}\left(\frac{a\mu+2bc}{b(\mu+2)}\right) = \frac{(a-bc)^3\mu^3(\gamma\mu-1)\rho_r\xi_r}{b(2+\mu)^3} > 0 \Leftrightarrow \frac{a\mu+2bc}{b(\mu+2)} < w_{\rho\xi r} \end{cases} \tag{4.19}$$

U_r is a quadratic function with regard to p and the axis of symmetry is $p = \frac{a+bw}{2b}$. Therefore, we can find the optimal retail price for $\gamma\mu > 1$. In order to clarify the calculation process, we discuss the intervals of w one by one as follows.

(a) when $c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$, $p_{c_1} = p^-$ and if $p_{c_2} = (\gamma+1)w - \gamma c$, $(\gamma+1)w - \gamma c < p^- < \frac{a+bw}{2b}$, thus, the optimal retail price is $p(w) = p^-$.

(b) when $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)}$, $p_{c_1} = (\gamma+1)w - \gamma c$ and $p_{c_2} = p^-_{\xi_r}$, $\frac{a+bw}{2b} \leqslant p^-_{\xi_r} < (\gamma+1)w - \gamma c$, thus, the optimal retail price will be $p(w) = p^-_{\xi_r}$.

(c) when $\frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \leqslant w < w_y$, the optimal retail price is $p(w) = p^-_{\xi r}$, where w_y is the unique real root of equation $Y(w) = 0$ (with regard to w).

$$\begin{aligned} Y(w) = &\mu\left[-a\mu + b\left(-2c + w(2+\mu)\right)\right] \\ &-b(w-c)^2\left[a\mu + b\left(c + c\gamma\mu - w(1+\mu+\gamma\mu)\right)\right]\rho_r\xi_r \end{aligned}$$

(d) when $w_y \leqslant w < w_{\rho\xi_r}$, the optimal retail price is $p(w) = \frac{(\mu+1)w-c}{\mu}$.

(e) when $w_{\rho\xi_r} \leqslant w < w_{\rho_r}$, $p_{c_1} = p_{c_2} = \frac{(\mu+1)w-c}{\mu}$, the optimal retail price is $p(w) = \frac{(\mu+1)w-c}{\mu}$.

(f) when $w_{\rho_r} \leqslant w < \frac{a\mu+bc}{b(\mu+1)}$, $p_{c_1} = p^-$ and $p_{c_2} = \frac{(\mu+1)w-c}{\mu}$, $\frac{a+bw}{2b} < p^- < \frac{(\mu+1)w-c}{\mu}$, the optimal retail price will be $p(w) = p^-$.

(g) when $\frac{a\mu+bc}{b(\mu+1)} \leqslant w < \frac{a}{b}$, $p_{c_1} = p^-$ and p_{c_2} is $\frac{a}{b}$, thus, the optimal retail price is $p(w) = p^-$.

Therefore, we can conclude the above discussion and derive the retailer's optimal retail price

$$p(w) = \begin{cases} p^-, c < w < \frac{a+2b\gamma c}{b(2\gamma+1)} \ \ or \ \ w_{\rho_r} \leqslant w < \frac{a}{b} \\ p^-_{\xi r}, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < w_y \\ \frac{(\mu+1)w-c}{\mu}, w_y \leqslant w < w_{\rho_r} \end{cases} \tag{4.20}$$

Proposition 4.1. *By comparison with the optimal retail price of traditional supply chain $p_t = \frac{(a+bw)}{2b}$, we derive*

(1) When $\gamma\mu \leqslant 1$ (RH1), we have

$$p_{h_1} \begin{cases} < p_t, c < w < \frac{a+2b\gamma c}{b(2\gamma+1)} \\ \geqslant p_t, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a}{b} \end{cases}$$

(2) When $\gamma\mu > 1$ (RC1 and RC2), we have

$$p(w)\begin{cases} < p_t, c < w < \frac{a+2b\gamma c}{b(2\gamma+1)} \ \ or \ \ w_y \leqslant w < \frac{a\mu+2bc}{b(\mu+2)} \\ \geqslant p_t, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < w_y \ \ or \ \ \frac{a\mu+2bc}{b(\mu+2)} \leqslant w < \frac{a}{b} \end{cases}$$

Proof. It is not difficult to demonstrate Proposition 4.1 based on the aforementioned six equivalent relationships (4.19). □

Proposition 4.1 implies that in the harmonious supply chain, the retailer charges a higher retail price as a response to the supplier setting a higher wholesale price, and charges a lower retail price to reciprocate a lower wholesale price in the harmonious supply chain. This result is consistent with that of Cui et al. (2007). In the acrimonious supply chain, however, the result is a little different: if $c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$ is regarded as a lower wholesale price interval and $\frac{a+2b\gamma c}{b(2\gamma+1)} < w < \frac{a}{b}$ as the higher wholesale price interval, the results shows that the reciprocal retailer may charge a retail price which is lower than p_t when the supplier's wholesale price is relatively high. We may attribute this abnormality to the supplier's intention perceived by the retailer. Figure 4.1 is used to illustrate the comparison. Up to now, we have merely calculated the retailer's best response when the wholesale price is given. Subsequently, the effects of the intention will be revealed more when the supplier and the retailer play a Stackelberg game and this kind of interaction which involving intention will make the game more interesting. We first investigate the channel in which the supplier is a profit-maximizer.

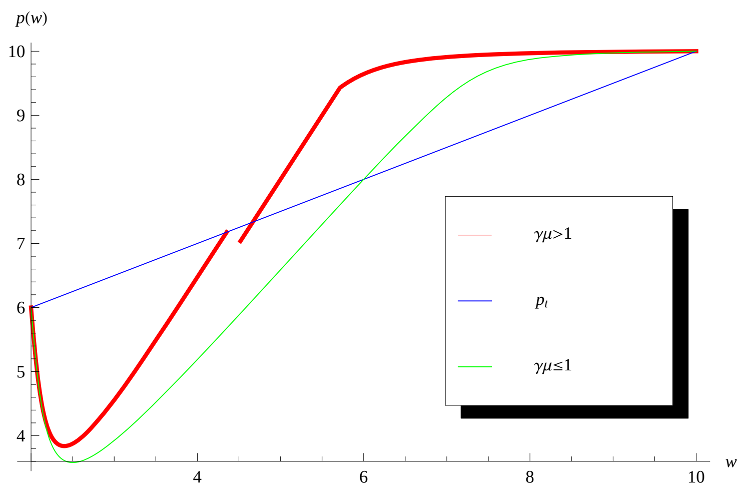

Figure 4.1: Comparison of the retailer's best response between traditional and reciprocal channel

4.3.2 Analysis of the Retailer's Best Response and the Intention

We have already discussed the retailer's best response in various scenarios when the wholesale price is given. These results will be meaningful to his best response so that we can know how the reciprocity affects the decision. Due to its complexity, the method of numerical analysis is used in the following discussion.

Proposition 4.2. *If $0 < \rho_r \leqslant \frac{4b}{(a-bc)^2}$, then $\frac{\partial(p^-(w))}{\partial w} > 0$ always holds in the interval $(c, \frac{a}{b})$; if $\rho_r > \frac{4b}{(a-bc)^2}$, then $\frac{\partial(p^-(w))}{\partial w} < 0$ when $c < w < w_{q2}$ and $\frac{\partial(p^-(w))}{\partial w} > 0$ when $w_{q2} < w < \frac{a}{b}$, where w_{q2} is the second smallest real root of equation $Q(w) = 0$, which has four real roots and*

$$Q(w) = -a^2\rho_r + b \left(\begin{array}{l} 4 - \left(\begin{array}{l} c(bc + a(2+4\gamma)) - 4(a+bc)(1+\gamma)w \\ +4b(1+\gamma)w^2 \end{array} \right) \rho_r \\ +(1+\gamma)(w-c)^2 \left(\begin{array}{l} a^2 + 2ab(c\gamma - (1+\gamma)w) \\ +b^2(-c^2\gamma + (1+\gamma)w^2) \end{array} \right) (\rho_r)^2 \end{array} \right) \tag{4.21}$$

Proof. See Appendix B.3. □

Proposition 4.2 tells us that it is possible that the retail price is decreasing with the wholesale price in an acrimonious supply chain, even if it occurs in a short interval, as illustrated in Figure 4.2 when the wholesale price is relatively low (of course, we can ensure that the short interval is valid). If $0 < \rho_r \leqslant \frac{4b}{(a-bc)^2}$, this counter-intuitive phenomenon will not happen. However, it would happen as long as $\rho_r > \frac{4b}{(a-bc)^2}$. The reason may lie in the following two points. Firstly, a kind action of the supplier is perceived by the reciprocal retailer while an increase in wholesale price brought on by other factors and it will not distort her kindness perceived by the retailer. For instance, the raise in price does not necessarily imply selfishness and unkindness. It may be a sort of self-protection action and can be understood (Kahneman et al., 1986b). Secondly, the supplier endows the reciprocation utility term with more weight ($\rho_r > \frac{4b}{(a-bc)^2}$) and thus enjoys more utility from the reciprocity. Furthermore, note that the retail price will not increase in the wholesale price indefinitely since $\lim_{w \to \frac{a}{b}} p^-(w) = \frac{a}{b}$.

Proposition 4.3. *The impact of the intention: for the harmonious supply chain ($\gamma\mu \leqslant 1$), the intention has no impact on the decisions of the supplier and the retailer; however, the intention does play an important role in the acrimonious supply chain ($\gamma\mu > 1$).*

It is worth noting that the scenario without considering intention and the scenario when

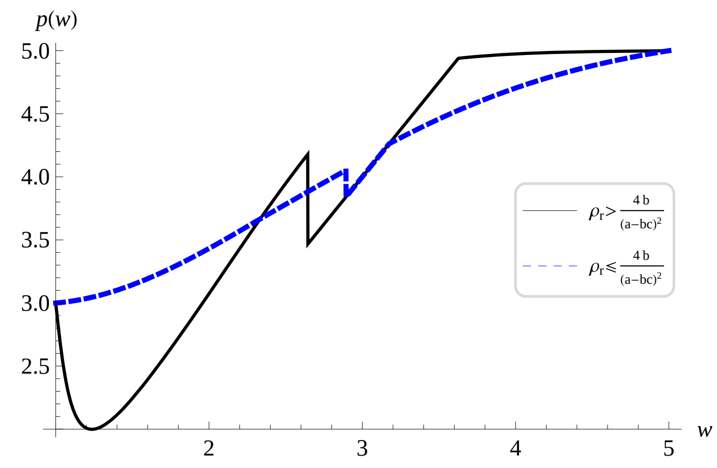

Figure 4.2: The reciprocal retailer's best response of the acrimonious channel

the intention is unambiguous lead to the same maximization problem. Two questions arises naturally: why should maximization for the scenario of unambiguous intention be equal to that in the scenario without considering the intention and how can we differentiate them? Though they seem to face the same maximization problem, they definitely have different results. In fact, we can find out the importance of the intention factor by comparing the response functions under the two scenarios. Firstly, when the supplier chooses the wholesale price from the interval $(c, \frac{a}{b})$, the intention-based (i.e., the supply chain of considering the intention) scenario has three different corresponding retail prices while it has only one for the non-intention-based scenario. Secondly, in our framework of supply chain, though it is possible to coordinate the supply chain in both the non-intention-based scenario and the intention-based scenario, they have different requirements for coordination. In order to compare them vividly, a graph is given below in Figure 4.3 ($a = 10, b = 1, c = 2, r = 1.2, \mu = 1, \rho_r = 2, \xi_r = 0.6$).

Proposition 4.4. *When the retailer's intention becomes more ambiguous (i.e., ξ_r is relatively small), the members are likely to make their decisions on the basis of the consequence, i.e., the rule of profit maximization; if the intention becomes less ambiguous (i.e., ξ_r is relatively great), the impact of the intention is likely to be more remarkable.*

Figure 4.4 describes the impacts of the retailer's intention on the retail prices of three cases: the cases when intention is greater and smaller and the case of no intention, i.e. traditional case. As you can see from Figure 4.4, the relationship between retail price p and wholesale price w is linear when the intention is not considered while it is non-linear after incorporating

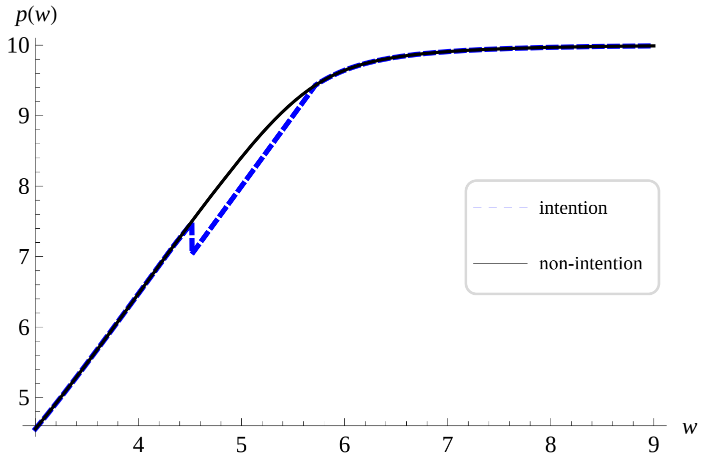

Figure 4.3: Comparison between two kinds of retail prices under intention-based and non-intention-based scenarios

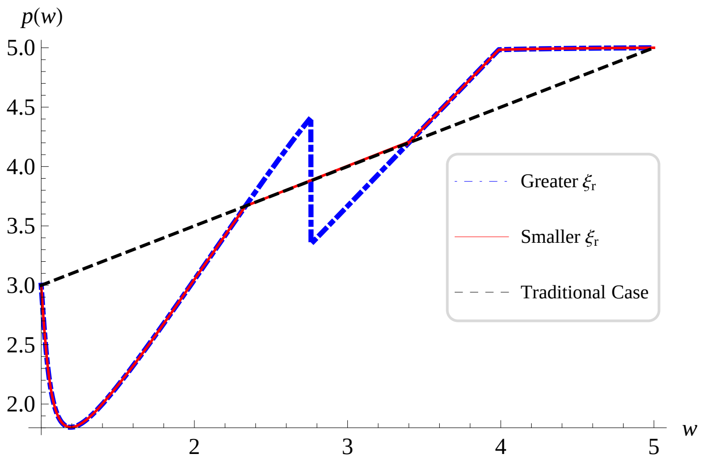

Figure 4.4: The impacts of the retailer's intention on retail prices

the intention into the supply chain. Additionally, when the intention becomes more ambiguous (i.e., smaller ξ_r), the part of the curve which is affected by the intention factor becomes linear and has a similar shape to the traditional case. In fact, the members' utility functions tell us a similar implication: when ξ_r decreases, the reciprocation utility term becomes smaller, which means the decisions that the retailer makes are more based on consequence than on intention. The reason is that when the intention is not obvious, the retailer tends to regard the consequence as his main basis of evaluating the supplier's kindness. The basis of consequence here, however, is not equal to the profit-maximizing rule since it implies the preference for fairness concern.

4.3.3 The Traditional Supplier's Decision

In this part, we analyze the traditional supplier's decisions first. That is, the only goal of the supplier is to maximize her profit $\pi_s(w) = (w-c)(a-bp(w))$ by charging her wholesale price w in anticipation of the retailer's best response through $p(w)$ given in Eq. (4.20). It might seem unreasonable to investigate this situation since only the retailer is concerned about fairness and intention. With the assumption of full information, it might seem that the retailer will also be concerned only with his profit because he knows the supplier is a selfish maximizer of profit. This is, however, not the case. It is possible that an 'economic person' deals with a 'behavioral person' and some researchers have looked into such situations (Cui et al., 2007). We will extend our analysis in next subsection to the case where the supplier has the same social preference as the retailer. In this subsection, we aim to get some important managerial insights through this relatively simple case and simultaneously provide a reference benchmark for the next part's analysis.

Similar to the analysis for the retailer, there are also two steps for the analysis of the traditional supplier's decisions. Firstly, we will find the most profitable wholesale price for the supplier in each of the three price intervals shown in Eq.(4.20). Secondly, the supplier derives her globally optimal payoff by comparing the resulting payoffs. When the intention is not incorporated into the supply chain, the globally optimal retail price for the retailer is $p(w) = p^-$, where $c < w < \frac{a}{b}$, and the supplier will incorporate this best response function into $\underset{w}{max}\ (w-c)(a-bp(w))$ to maximize her utility (i.e., her profit) by choosing the optimal wholesale price. For the sake of simplicity, we leave the detailed derivations to Appendix B.2.

So far, we have shown that there are four optimal equilibria when $\gamma\mu > 1$. They are $(w_{h3}, p^-(w_{h3}))$, $\left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right)$, $(w_{\xi h3}, p^-(w_{\xi h3}))$ and $\left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right)$. We are going to analyze in which cases a constant wholesale-price contract will be able to coordinate the channel. Therefore, we will discuss the four equilibria respectively as (1) and (4) here.

(1) The wholesale price $w = \frac{(a+bc)\mu+2bc}{2b(1+\mu)}$ can be used to coordinate the channel since the corresponding retail price is $p = \frac{a+bc}{2b}$;

(2) We will show that the channel cannot be coordinated at equilibrium $(w_{h3}, p^-(w_{h3}))$. When the optimal retail price is p^-, the channel can be coordinated if and only if $p^- = \frac{a+bc}{2b}$.

Then we derive corresponding wholesale price

$$w_o = \frac{a\rho_r(a-bc) - 4b + bc\rho_r(1+2\gamma)(a-bc)}{2b\rho_r(a-bc)(1+\gamma)} \tag{4.22}$$

After substituting Eq. (4.22) into $f_h(w)$ (recall that w_{h3} is the largest real root of equation $f_h(w) = 0$) and simplifying it, we get

$$w_q = \frac{16b^2 + 8b(a-bc)^2\gamma\rho_r - (a-bc)^4\gamma(\rho_r)^2}{(a-bc)^2(1+\gamma)(\rho_r)^2} \tag{4.23}$$

Thus, w_o is equivalent to w_{h3} as long as Eq. (4.23) equals 0, i.e., $16b^2 + 8b(a-bc)^2\gamma\rho_r - (a-bc)^4\gamma(\rho_r)^2 = 0$. However, we know that equation $f_h(w) = 0$ has three real roots, they are w_{h1}, w_{h2} and w_{h3}, and also $w_{h1} < c < w_{h2} < w_{h3}$. We have demonstrated that $w_{h_1} < c < w_{h_2} < \frac{a+bc(1+2\gamma)}{2b(1+\gamma)} < w_{h3} < \frac{a}{b}$. Additionally, it is possible to derive that $w_o < \frac{a+bc(1+2\gamma)}{2b(1+\gamma)}$. Therefore, w_o cannot be equal to w_{h3} and thus the channel cannot be coordinated when the reciprocal supplier charges the wholesale price w_{h3}.

(3) Since equilibrium $\left(w_{\xi h3}, p^-(w_{\xi h3})\right)$ is very similar to equilibrium $(w_{h3}, p^-(w_{h3}))$, we can show in a similar way that the wholesale price $w_{\xi h3}$ is not able to coordinate the channel in this case either.

(4) When the optimal retail price is w_y, the channel can be coordinated if and only if $\frac{(\mu+1)w_y - c}{\mu} = \frac{a+bc}{2b}$, i.e., $w_y = \frac{(a+bc)\mu+2bc}{2b(1+\mu)}$. However, $\frac{(a+bc)\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}$ is necessary for the existence of equilibrium $\left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right)$, which means w_y fails to coordinate the channel.

When $\gamma\mu \leqslant 1$, there exists only one equilibrium, i.e., $(w_{h3}, p^-(w_{h3}))$ and we have demonstrated that it leads to incoordination of the channel.

We can summarize these results in the following proposition 4.5.

Proposition 4.5. *(1). When $\gamma\mu \leqslant 1$, at equilibrium, the supplier sets a wholesale price $w = w_{h3}$ and the retailer, in response, sets the retail price at $p = p^-(w_{h3})$. The payoffs of the supplier and the retailer are $\pi_s = (w_{h3} - c)\left[a - bp^-(w_{h3})\right]$ and $\pi_r = \left[p^-(w_{h3}) - w_{h3}\right]\left[a - bp^-(w_{h3})\right]$ respectively. Additionally, the reciprocal channel cannot be coordinated by any means. (2).*

When $\gamma\mu > 1$, the equilibrium is

$$(w_{gl}^*, p_{gl}^*) = \begin{cases} \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right) \;\; if \;\; CON1 \\ \left(w_{h3}, p^-\left(w_{h3}\right)\right) \;\; if \;\; CON2 \\ \left(w_{\xi h3}, p_{\xi_r}^-\left(w_{\xi h3}\right)\right) \;\; if \;\; CON3 \\ \left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right) \;\; if \;\; CON4 \end{cases}$$

where CON1, CON2, CON3 and CON4 are very complicated constraints, but they can be found in Appendix B.2. In this case, the supplier can coordinate the reciprocal channel with a wholesale-price contract if $\left(c < w_y \leqslant \frac{(a+bc)\mu+2bc}{2b(1+\mu)}\right) \wedge \left[\left(c < w_{h3} \leqslant w_{\rho_r}\right) \vee \left(\pi_s^{1.2} \leqslant \frac{(a-bc)^2\mu}{4b(1+\mu)}\right)\right]$ [6]*, where* $\pi_s^{1.2} = \left(w_{h3} - c\right)\left[a - bp^-\left(w_{h3}\right)\right]$*. By charging a wholesale price* $\frac{(a+bc)\mu+2bc}{2b(1+\mu)}$ *which is higher than her marginal cost, the supplier can achieve channel coordination and obtain a payoff of* $\pi_s = \frac{(a-bc)^2\mu}{4b(1+\mu)}$*. The retailer reciprocates by setting his retail price at* $p = \frac{a+bc}{2b}$ *and gets a payoff of* $\pi_r = \frac{(a-bc)^2}{4b(1+\mu)}$*.*

Proposition 4.5 concludes the equilibria of the channels (roughly speaking, it is a harmonious channel when $\gamma\mu \leqslant 1$ and an acrimonious channel when $\gamma\mu > 1$) in which a traditional supplier plays a game with a reciprocal retailer (who has a preference for reciprocity). It is well known that the supplier is not able to achieve the maximum channel profit with only a constant wholesale price if the two members solely care about their own monetary payoffs (Jeuland and Shugan, 1983). However, proposition 4.5 implies that the supplier may be able to achieve it as long as some constraints can be satisfied when $\gamma\mu > 1$. Unfortunately and strangely, however, the channel can never be coordinated if $\gamma\mu \leqslant 1$. This is probably because there is no conjecture about the intentions in harmonious channel and both players tend to maximize their own profits since both parties' intentions are clear. It is also worth noting that the supplier's wholesale price is greater than her marginal cost when the channel is coordinated. Furthermore, the supplier's wholesale price of this reciprocal channel is relatively lower compared with the optimal wholesale price in the corresponding traditional channel (both w_{h3} and $\frac{(a+bc)\mu+2bc}{2b(1+\mu)}$ are smaller than $\frac{a+bc}{2b}$).

[6] $\wedge$ signifies "and" and $\vee$ signifies "or" throughout this chapter. For example, if $A \wedge [B \vee C]$ is the precondition, it means that only when A and B are simultaneously satisfied or only when A and C are simultaneously satisfied can the result be derived.

4.3.4 The Reciprocal Supplier's Decision

We assume that the supplier has the same preference for reciprocity as the retailer. Therefore, we can easily write out the mathematical expression of retailer's intention which perceived by the supplier as follows:

$$\theta_r = \begin{cases} \left.\begin{array}{l} 1, \exists \tilde{p} \quad \pi_s(w'', p') > \pi_s(w'', \tilde{p}) \\ and \quad \pi_r(w'', \tilde{p}) \geqslant \gamma \pi_s(w'', \tilde{p}) \\ \xi_s, otherwise \end{array}\right\} if \quad \pi_s(w'', p') \geqslant \mu \pi_r(w'', p') \\ \left.\begin{array}{l} 1, \exists \tilde{p} \quad \pi_s(w'', p') < \pi_s(w'', \tilde{p}) \\ and \quad \pi_r(w'', \tilde{p}) \geqslant \gamma \pi_s(w'', \tilde{p}) \\ \xi_s, otherwise \end{array}\right\} if \quad \pi_s(w'', p') < \mu \pi_r(w'', p') \end{cases} \tag{4.24}$$

Similarly, we can calculate successively the intervals of θ_r that can satisfy the conditions in above four circumstances respectively. For simplicity's sake, we omit the process of calculation here. To sum up, when $(\gamma+1)w'' - \gamma c > \frac{w''(1+\mu)-c}{\mu}$, i.e., $\gamma\mu > 1$, there are two possibilities for θ_r: if $\frac{w''(1+\mu)-c}{\mu} < p' \leqslant (\gamma+1)w'' - \gamma c$, then $\theta_r = \xi_s$; if $w'' < p' \leqslant \frac{w''(1+\mu)-c}{\mu}$ or $(\gamma+1)w'' - \gamma c < p'$, then $\theta_r = 1$. When $(\gamma+1)w'' - \gamma c \leqslant \frac{w''(1+\mu)-c}{\mu}$, i.e., $\gamma\mu \leqslant 1$, $\theta_r = 1$ always holds.

Correspondingly, the supplier has the following three scenarios similar to those of the retailer.

1. **Harmonious Supply Chain** ($\gamma\mu \leqslant 1$)

(SH1). Unambiguous Kindness. The supplier's optimization problem is given by

$$\max_w \ (w-c)(a-bp) + \rho_s(a-bp')^2 \left[w''(\mu+1) - \mu p' - c\right] \left(w'' - w\right) \tag{4.25}$$

$$s.t. \quad w < p < \frac{a}{b} \tag{4.26}$$

2. **Acrimonious Supply Chain** ($\gamma\mu > 1$)

(SC1). Unambiguous Kindness. The supplier's optimization problem is given by

$$\max_w \ (w-c)(a-bp) + \rho_s(a-bp')^2 \left[w''(\mu+1) - \mu p' - c\right] \left(w'' - w\right) \tag{4.27}$$

$$s.t. \quad w < p \leqslant \frac{w(1+\mu)-c}{\mu} \ or \ (\gamma+1)w - \gamma c < p \tag{4.28}$$

(SC2). Ambiguous Unkindness. The supplier's optimization problem is given by

$$\max_{w} \ (w-c)(a-bp)+\rho_s\xi_s(a-bp')^2\left[w''(\mu+1)-\mu p'-c\right]\left(w''-w\right) \tag{4.29}$$

$$s.t. \quad \frac{w(1+\mu)-c}{\mu} < p \leqslant (\gamma+1)w-\gamma c \tag{4.30}$$

In the scenario of RH1-SH1 [7], i.e., $\gamma\mu \leqslant 1$, the supplier will go to find an optimal wholesale price to maximize his utility in anticipation of $p(w)$ given in Eq. (4.12). Therefore, the reciprocal supplier's decision reduces to the following optimization problem:

$$\max_{w} \ (w-c)(a-bp)+\rho_s(a-bp')^2\left[w''(\mu+1)-\mu p'-c\right]\left(w''-w\right) \tag{4.31}$$

$$s.t. \quad p=p^{-}(w), w<p<\frac{a}{b} \tag{4.32}$$

The first-order condition of Eq. (4.31) is

$$a-bp(w)-b(w-c)\frac{\partial\left(p(w)\right)}{\partial w}-\rho_s(a-bp')^2\left[w''(\mu+1)-\mu p'-c\right]=0 \tag{4.33}$$

In the equilibrium, we assume that the beliefs equal the real actions. Therefore, the supplier's optimal wholesale price will be the solution of the following equation: [8]

$$a-bp(w)-b(w-c)\frac{\partial\left(p(w)\right)}{\partial w}-\rho_s(a-bp(w))^2\left[w(\mu+1)-\mu p(w)-c\right]=0 \tag{4.34}$$

where $p(w)=p^{-}$.

When $\gamma\mu > 1$, likewise, the reciprocal supplier will solve the following three optimization problems for charging optimal wholesale price respectively in anticipation of $p(w)$ given in Eq. (4.20) and then compare the results to get the global wholesale price.

Case 1

$$\max_{w} \ (w-c)(a-bp)+\rho_s(a-bp')^2\left[w''(\mu+1)-\mu p'-c\right]\left(w''-w\right) \tag{4.35}$$

[7] RH1-SH1 represents the context of a Stackelberg game. As the leader, the supplier makes her decision first. However, before making the decision, she has to predict the optimal decision of the retailer $p(w)$. Then, as a response function, the optimal $p(w)$ will be incorporated into the supplier's utility function to derive her optimal decision. RC1-SC1 and RC2-SC2 have the similar meaning.

[8] Unfortunately, it is impossible to derive the analytical solution. Thus, Eq. (4.34) is used to represent the supplier's optimal decision.

$$s.t. \quad p = p^{-}(w), c < w < \frac{a+2b\gamma c}{b(2\gamma+1)} \;\; or \;\; w_{\rho_r} \leqslant w < \frac{a}{b} \tag{4.36}$$

Case 2

$$\max_{w} \; (w-c)(a-bp) + \rho_s \xi_s (a-bp')^2 \left[w''(\mu+1) - \mu p' - c\right] \left(w'' - w\right) \tag{4.37}$$

$$s.t. \quad p = p^{-}_{\xi_r}(w), \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < w_y \tag{4.38}$$

Case 3

$$\max_{w} \; (w-c)(a-bp) + \rho_s (a-bp')^2 \left[w''(\mu+1) - \mu p' - c\right] \left(w'' - w\right) \tag{4.39}$$

$$s.t. \quad p = \frac{(\mu+1)w - c}{\mu}, w_y \leqslant w < w_{\rho_r} \tag{4.40}$$

Because of the complexity of the supplier's utility function, we are not able to derive the optimal wholesale price in a way which can be expressed analytically. However, the existence and the uniqueness of the optimal wholesale price for the three cases are demonstrated in Appendix B.4.1. Intention-based approaches explain more stylized facts from experiments but, in terms of tractability, come at a cost. Nevertheless, their explanatory power justifies their complexity (Korth, 2009).

When $\gamma\mu > 1$, there are also four optimal equilibria for this reciprocal channel in which both members have the preference for reciprocity. They are $(w_{rsp}, p^{-}(w_{rsp}))$, $\left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right)$, $\left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right)$ and $\left(w_{\xi rsp}, p^{-}(w_{\xi rsp})\right)$. In the discussion above, we have demonstrated that the wholesale price $\frac{(a+bc)\mu+2bc}{2b(1+\mu)}$ can coordinate the channel while w_y cannot, and that holds true in this channel also. Thus, we next focus on analyzing the remaining two equilibria. Considering equilibrium $(w_{rsp}, p^{-}(w_{rsp}))$, it can coordinate the channel if and only if the following equation has a real root:

$$(a-bp) - b(w-c)\frac{dp}{dw} - \rho_s (a-bp)^2 \left[w(\mu+1) - \mu p - c\right] = 0 \tag{4.41}$$

where $p = p^{-}$ and $w = w_o$ of Eq. (4.22).

By MATHEMATICA, it is not difficult to show that Eq. (4.41) has no real root, which means the wholesale price w_{rsp} cannot be used to coordinate the channel. Likewise, $w_{\xi rsp}$ also fails to coordinate the channel either.

Therefore, it is straightforward to know that the channel cannot achieve coordination when $\gamma\mu \leqslant 1$. We thus summarize these results in the following proposition 4.6.

Proposition 4.6. *(1) If $\gamma\mu \leqslant 1$, the reciprocal channel cannot be coordinated with a wholesale-price contract. At equilibrium, the supplier sets a wholesale price $w = w_{rsp}$ and the retailer, in response, charges the retail price at $p = p^{-}(w_{rsp})$. The payoffs of the supplier and the retailer are $\pi_{bs} = (w_{rsp} - c)\left[a - bp^{-}(w_{rsp})\right]$ and $\pi_{br} = \left[p^{-}(w_{rsp}) - w_{rsp}\right]\left[a - bp^{-}(w_{rsp})\right]$ respectively. (2) If $\gamma\mu > 1$, the equilibrium is*

$$(w^*_{rgl}, p^*_{rgl}) = \begin{cases} \left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right) & if \;\; RCON1 \\ \left(w_{rsp}, p^{-}\left(w_{rsp}\right)\right) & if \;\; RCON2 \\ \left(w_{\xi rsp}, p^{-}_{\xi_r}\left(w_{\xi rsp}\right)\right) & if \;\; RCON3 \\ \left(w_y, \frac{(\mu+1)w_y - c}{\mu}\right) & if \;\; RCON4 \end{cases} \tag{4.42}$$

where RCON1, RCON2, RCON3 and RCON4 are complex constraints shown in Appendix B.4. In this case, the supplier can coordinate the reciprocal channel with a wholesale-price contract when $\left(c < w_y \leqslant \frac{(a+bc)\mu+2bc}{2b(1+\mu)}\right) \wedge \left[\left(c < w_{rsp} \leqslant w_{\rho_r}\right) \vee \left(\pi^{A2}_s \leqslant \frac{(a-bc)^2\mu}{4b(1+\mu)}\right)\right]$, where $\pi^{A2}_s = (w_{rsp} - c)\left[a - bp^{-}\left(w_{rsp}\right)\right]$. By charging a wholesale price $w = \frac{(a+bc)\mu+2bc}{2b(1+\mu)}$ which is higher than her marginal cost, the supplier can achieve channel coordination and obtain a payoff of $\pi_{bs} = \frac{(a-bc)^2\mu}{4b(1+\mu)}$. The retailer reciprocates by setting his retail price at $p = \frac{a+bc}{2b}$ and gets a payoff of $\pi_{br} = \frac{(a-bc)^2}{4b(1+\mu)}$.

Carefully analysis of the constraint of proposition 4.6 reveals that it has nothing to do with ξ_s, which means the intention of the retailer perceived by the supplier will not affect the possibility of a channel's coordination when both members have the preference for reciprocity. It is well known that the supplier benefits more than the retailer in the traditional Stackelberg game if the information is perfect, which means the leader has the first-mover advantage. However, if we incorporate intention into this game, the supplier has to guess the retailer's intention before she moves and thus, this advantage may disappear, or if not, be reduced since our result shows that the supplier's guess has no impact on the coordination of the channel.

4.4 Numerical Analysis

When both the supplier and the retailer have preferences of reciprocity, we have derived complicated equilibria which make it difficult to obtain interesting managerial implications, especially when $\gamma\mu > 1$. Therefore, in this part, we are going to analyze the impacts of some important parameters, such as γ, μ, ξ_r, and ξ_s, on the equilibrium of an acrimonious channel (we omit the analysis of harmonious channel since it is a special case and both parties' intention is clear) by using numerical analysis. It would be beneficial to examine the equilibria carefully before we do this. According to Eq. (4.42), there are four pairs of equilibria in terms of different conditions in the acrimonious channel. The first pair of equilibria $\left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right)$ is simple: the optimal wholesale price is affected by a, b, c and μ and the optimal retail price is even simpler. This equilibrium is a special since it can coordinate the channel, hence we call it the "Coordinating Equilibrium". The following three pairs of equilibria are much more complex. The second one $(w_{rsp}, p^{-}(w_{rsp}))$ doesn't involve the conjecture of intention, so we call it the "Non-intention Equilibrium". In fact, this equilibrium is also the optimal solution when $\gamma\mu \leqslant 1$, that is, the two players know the other party's intention very well in harmonious channel. The fourth one $\left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right)$ can be called the "No-supplier Equilibrium" since it doesn't involve the supplier's two important parameters: ρ_s and θ_r. The third one $\left(w_{\xi rsp}, p^{-}_{\xi r}(w_{\xi rsp})\right)$ includes all the parameters and thus can be called the "Comprehensive Equilibrium". We start this part by analyzing γ first.

Table 4.1: The influence of γ on the reciprocal equilibrium, the supplier's profit and the retailer's profit in the reciprocal channel.

γ	w^*	p^*	π_s	π_r	$\pi_s - \mu\pi_r$	$\pi_r - \gamma\pi_s$
1.2	4.52142	7.04284	7.45624	7.45624	0	−1.49125
1.5	4.33738	6.67475	7.77237	7.77234	0.00003	−3.88622
1.8	4.18493	6.36986	7.9316	7.9316	0	−6.34528
2.1	4.05672	6.11345	7.99355	7.99358	−0.00003	−8.79288
2.4	4	6	8	8	0	−11.2
2.7	4	6	8	8	0	−13.6
3.0	4	6	8	8	0	−16
3.3	4	6	8	8	0	−18.4
3.6	4	6	8	8	0	−20.8
3.9	4	6	8	8	0	−23.2

Note: (w^*, p^*) is the reciprocal equilibrium. $a = 10, b = 1, c = 2, \mu = 1, \rho_r = 2, \xi_r = 0.5, \rho_s = 2, \xi_s = 0.5$.

The increase in γ implies that the retailer raises his fairness benchmark, which means his requirement for profit is more difficult to satisfy when other parameters remain the same. Therefore, the supplier and the retailer tend to have conflicts and thus both the wholesale price and the retail price rise. However, Table 4.1 shows that the two members may be in a harmonious state. Both prices are decreasing with γ until they reach the Coordinating Equilibrium. The possible explanation is that as the first mover, the supplier didn't perceive unkindness from retailer (note that $\pi_s - \mu\pi_r \geqslant 0$ holds nearly for all the data), so she believes that the retailer is kind and thus lowers the wholesale price. The retailer reciprocates the supplier for her kindness by reducing his price too.

Table 4.2: The influence of μ on the reciprocal equilibrium, the supplier's profit and the retailer's profit in the reciprocal channel.

μ	w^*	p^*	π_s	π_r	$\pi_s - \mu\pi_r$	$\pi_r - \gamma\pi_s$
1.2	4.68369	6.92011	8.26547	6.88793	−0.000046	−3.03063
1.5	4.8729	6.78816	9.2273	6.15151	0.000035	−4.92125
1.8	5.01965	6.69724	9.97318	5.54068	−0.000044	−6.42714
2.1	5.13849	6.63301	10.5673	5.03203	0.000037	−7.64873
2.4	5.23789	6.587	11.0509	4.60451	0.000076	−8.65657
2.7	5.32312	6.5539	11.4518	4.24139	0.000047	−9.50077
3.0	5.39765	6.5302	11.7892	3.92972	0.00004	−10.2173
3.3	5.46388	6.51354	12.0767	3.6596	0.00002	−10.8324
3.6	5.5235	6.50224	12.3244	3.4234	0.00016	−11.3659
3.9	5.57773	6.4951	12.5396	3.21529	−0.000031	−11.8322

Note: $a = 10, b = 1, c = 2, \gamma = 1.2, \rho_r = 2, \xi_r = 0.5, \rho_s = 2, \xi_s = 0.5$.

Increasing μ represents the increase in the supplier's reference profit. Thus, it would be difficult to satisfy the supplier's requirement for the profit and she will increase her wholesale price, just as shown in Table 4.2. As a reciprocal player, the retailer should have raised his price as a response, because he perceives the unkindness from the supplier since $\pi_r - \gamma\pi_s < 0$. This table, however, shows us an opposite result. The possible explanation lies in the following two points: (1) the intention behind the unkindness perceived by the retailer is not very clear ($\xi_r = \xi_s = 0.5$); (2) before the retailer knows clearly what the underlying intention of the supplier's action is, he is likely to make a strategy to minimize his loss or maximize his profit. The retailer's best retail price p^* of Table 4.2 reflects this, because both the speed at which the wholesale price increase and the speed at which the retailer profit decreases are declining as μ increases. Therefore, the intention plays an important role in decisions, but other factors, such as the sequence of the game, may also have influence, especially when both parties are not very sure about the other party's intention.

Table 4.3: The influence of unit cost c on the reciprocal equilibrium, the supplier's profit, the retailer's profit and the total channel's profit in the reciprocal channel.

c	w^*	p^*	π_s	π_r	π_T
1.2	3.9617	6.72344	9.048943372474374	9.048943372474373	18.098
1.5	4.1683	6.8366	8.440854817552468	8.440854817552468	16.882
1.8	4.3749	6.9499	7.853871512076759	7.853871512076759	15.7077
2.1	4.5816	7.0632	7.287994997404566	7.287994997404568	14.5760
2.4	4.7882	7.1765	6.743227072056571	6.743227072056570	13.4865
2.7	4.9949	7.2899	6.219569842500957	6.219569842500957	12.4391
3.0	5.2016	7.4033	5.717025785285915	5.717025785285915	11.4341
3.3	5.4084	7.5168	5.2355978232379	5.2355978232379	10.4712
3.6	5.6152	7.6303	4.775289419075012	4.775289419075014	9.5506
3.9	5.8220	7.7439	4.336104690512914	4.336104690512913	8.6722

Note: π_T is the total channel's profit. $a = 10, b = 1, \gamma = 1.2, \mu = 1, \rho_r = 2, \rho_s = 2, \xi_r = 0.9, \xi_s = 0.9$.

Table 4.4: The influence of unit cost c on the conventional equilibrium, the supplier's profit, the retailer's profit and the total channel's profit in the conventional channel.

c	w^*	p^*	π_s	π_r	π_T
1.2	5.6	7.8	9.68	4.84	14.52
1.5	5.75	7.875	9.03125	4.515625	13.546875
1.8	5.9	7.95	8.405	4.2025	12.6075
2.1	6.05	8.025	7.80125	3.900625	11.701875
2.4	6.2	8.1	7.22	3.61	10.83
2.7	6.35	8.175	6.66125	3.330625	9.991875
3.0	6.5	8.25	6.125	3.0625	9.1875
3.3	6.65	8.325	5.61125	2.805625	8.416875
3.6	6.8	8.4	5.120	2.56	7.680
3.9	6.95	8.475	4.65125	2.325625	6.976875

Note: $a = 10, b = 1, \gamma = 1.2, \mu = 1, \rho_r = 2, \rho_s = 2, \xi_r = 0.9, \xi_s = 0.9$.

Tables 4.3 and 4.4 are used to compare the impacts of unit cost c on the supplier's and the retailer's prices and their profits in reciprocal and conventional channel, respectively. The wholesale prices and the retail prices are increasing with the unit cost c in the two channels, but both the wholesale price and the retail price are lower in the reciprocal channel. In addition, the difference between the supplier's profit and the retailer's profit becomes smaller in the reciprocal channel while in the conventional channel, the supplier gains a large share of the total profit since she has "first mover advantage" and doesn't have a preference for reciprocity. The total profit of the supply chain is greater in the reciprocal channel. The above results may be caused by the following reason. In the conventional channel, neither the supplier nor the retailer has a preference for reciprocity and they are solely profit maximizers, so the raise in c may aggravate the conflict between the two players. In the reciprocal channel, however, both players not only care about consequence but also its underlying intention. The increase in unit cost is uncontrollable and the retailer knows this, so it is understandable that the supplier increases her price and thus the retailer slowly increases the retail price as a response, which improves the whole channel efficiency compared with the conventional channel.

Table 4.5 shows that in the acrimonious channel, both the supplier and the retailer will

Table 4.5: The influence of ξ_s on the reciprocal equilibrium, the supplier's profit and the retailer's profit in the reciprocal channel.

ξ_s	w^*	p^*	$\pi_s(\times 10^{-3})$	$\pi_r(\times 10^{-3})$	$\pi_s - \mu\pi_r$	$\pi_r - \gamma\pi_s$
0.05	0.24281515	0.26426509	6.4284537654999	3.22059	-3.3478×10^{-4}	-5.792×10^{-5}
0.15	0.24281522	0.26426513	6.4284537654641	3.22058	-3.3476×10^{-4}	-5.793×10^{-5}
0.2	0.24281526	0.26426514	6.4284537654326	3.22057	-3.3475×10^{-4}	-5.794×10^{-5}
0.3	0.24281533	0.26426518	6.4284537653423	3.22056	-3.3472×10^{-4}	-5.795×10^{-5}
0.4	0.2428154	0.264265215	6.4284537652162	3.22055	-3.3470×10^{-4}	-5.796×10^{-5}
0.5	0.24281547	0.264265251	6.4284537650542	3.22054	-3.3468×10^{-4}	-5.797×10^{-5}
0.6	0.24281554	0.264265287	6.4284537648569	3.22053	-3.3466×10^{-4}	-5.798×10^{-5}
0.7	0.24281561	0.264265323	6.4284537646228	3.22052	-3.3463×10^{-4}	-5.799×10^{-5}
0.8	0.24281569	0.264265358	6.4284537643528	3.22051	-3.3461×10^{-4}	-5.800×10^{-5}
0.9	0.24281576	0.264265394	6.4284537640470	3.22050	-3.3459×10^{-4}	-5.801×10^{-5}

Note: In order to show the meaning of $\pi_s(\times 10^{-3})$, an example is given as follows: the supplier's profit is $6.4284537654999 \times 10^{-3}$ when $\xi_s = 0.05$. $\pi_r(\times 10^{-3})$ has a similar meaning. Additionally, $a = 2, b = 7, c = 0.2, \gamma = 0.51, \mu = 2.1, \rho_r = 1, \rho_s = 0.1, \xi_r = 0.3$.

increase their prices as ξ_s becomes greater, which leads to lower profits for both parties. This is because when the intention of the retailer perceived by the supplier ξ_s increases in the range of $(0, 1)$, and simultaneously the supplier perceives unkindness ($\pi_s - \mu\pi_r < 0$) from the retailer, the supplier will strike first to gain the advantage by rasing her price. This brings home to the retailer that the supplier is unkind to him (he may think the supplier is kind at the first beginning), so it is natural for him to raise the retail price. This conflict results in the decreasing channel efficiency, even though this may be a misunderstanding.

The results of Table 4.6 show that the impact of ξ_r on equilibrium is totally different from that of ξ_s. As ξ_r increases from 0.05 to 0.9, both the equilibrium wholesale price and the equilibrium retail price are decreasing. This is a little odd, especially the retailer did not get what he wanted ($\pi_r - \gamma\pi_s < 0$). A possible explanation is as follows. As the first mover of the game, the supplier perceives a little unkindness from the retailer since $\pi_s - \mu\pi_r < 0$ happens occasionally, but it appears sporadically and the degree is very small (-0.00003). In addition,

Table 4.6: The influence of ξ_r on the reciprocal equilibrium, the supplier's profit and the retailer's profit in the reciprocal channel.

ξ_r	w^*	p^*	π_s	π_r	$\pi_s - \mu\pi_r$	$\pi_r - \gamma\pi_s$
0.05	4.59693	7.19387	7.28732	7.28735	−0.00003	−1.45743
0.15	4.55398	7.10797	7.38619	7.38622	−0.00003	−1.47721
0.2	4.5443	7.0886	7.40748	7.40748	0	−1.48150
0.3	4.53265	7.06529	7.43259	7.43256	0.00003	−1.48655
0.4	4.52586	7.05173	7.44692	7.44695	−0.00003	−1.48935
0.5	4.52142	7.04284	7.45624	7.45624	0	−1.49125
0.6	4.51828	7.03656	7.46277	7.46277	0	−1.49255
0.7	4.51594	7.03189	7.46759	7.46762	−0.00003	−1.49349
0.8	4.51414	7.02828	7.47132	7.47132	0	−1.49426
0.9	4.5127	7.0254	7.47428	7.47428	0	−1.49486

Note: $a = 10, b = 1, c = 2, \gamma = 1.2, \mu = 1, \rho_r = 2, \rho_s = 2, \xi_s = 0.5$.

the intention is not clear ($\xi_s = 0.5$). Thus, the supplier has no reason to punish the retailer and thus reduces the wholesale price since she knows the benefit of reciprocity and cooperation. Although the retailer perceives unkindness from the supplier and the intention factor equals 0.9 (0.9 doesn't mean that the retailer believes the probability of this unkindness is 90 percent), he still chooses to reward the supplier by reducing his price, perhaps the real action overcomes the conjecture.

4.5 Concluding Remarks and Future Research

In this chapter, we take an initial step to incorporating the members' preferences of reciprocity into a dyadic channel, where the supplier acts as a Stackelberg leader in setting wholesale price and the retailer acts as a follower in charging a retail price accordingly. The preference for reciprocity emphasizes that decision makers not only consider the consequence of one action which is caused by the other party but also consider the intention behind it in order to evaluate the other party's kindness or unkindness as a basis for reward or punishment. Past studies in behavioral economics and marketing have shown that fairness concern is an important norm and thus it has received much more attention than has been paid to intention. The preference for fairness concern, however, mainly stresses the importance of consequence of an action solely while neglecting the influence of the intention. More and more behavioral experiments show that the intention behind the action may be decisive. Therefore, it is meaningful to study the preferences of reciprocity and to explore their implications for channel coordination.

Our analysis shows that the reciprocal channel can be coordinated by using a constant wholesale price in the acrimonious supply chain ($\gamma\mu > 1$), which implies that the problem of double marginalization is not necessarily present all the time. This result may be helpful to explain why the wholesale-price contract is widespread – aside from its simplicity of operation, another important reason may lie in that it has the potential of increasing both parties' utilities as long as they have a preference for reciprocity. However, it is impossible to coordinate the channel with a wholesale-price contract in the harmonious supply chain ($\gamma\mu \leqslant 1$).

This chapter also shows that compared with traditional retail price, the retailer charges a lower retail price to reward the supplier's lower wholesale price and a higher retail price to punish the supplier's higher wholesale price in the harmonious supply chain. This kind of reciprocation is reasonable and intuitive and is consistent with the result of Cui et al. (2007) in which the members of the supply chain are fairness-concerned but not intention-concerned. In the acrimonious supply chain, however, the retailer may charge a price which is lower than the optimal retail price of traditional channel p_t when the supplier's wholesale price is relatively high. This result is counter-intuitive and is different from that of the supply chain in which the members are solely fairness-concerned, and thus the difference between them may be attributed to the members' intention-concerned preference.

In addition, our study implies that when $\gamma\mu > 1$, the retail price may decrease in the wholesale price when the wholesale price changes from c to $\frac{a}{b}$ as long as ρ_r is relatively great ($\rho_r > \frac{4b}{(a-bc)^2}$), though this result exists only in a short beginning interval. This counter-intuitive phenomenon will not appear in a fairness-concerned channel. Furthermore, when the supplier's intention perceived by the retailer ξ_r is ambiguous, no matter the intention is perceived as kind or unkind, the retailer is inclined to make his decision the same as he would in a traditional channel. On the other hand, when the supplier's intention perceived by the retailer is relatively obvious, his decision is quite different. Therefore, based on some counter-intuitive results which will never happen in traditional channels and fairness-concerned channels, we conclude that the members' intentions do have impacts on the supply chain's decisions and channel coordination, which implies that our initial step of incorporating intention-concerned preference into the supply chain is valuable.

Chapter 5

Conclusions and Future Research

5.1 Conclusions

OM has been the hot issue in industry and academia. Traditional researches of OM is based on the ideal hypothesis of "completely rational person" or assume that the decision-makers can be led to make rational actions. However, the real world is complicated and uncertain and there are complexity and variability in our daily life. Under this condition, people's actions often show that they are "bounded rationality", which can be reflected by many behavioral preferences, such as reference dependence and loss aversion, fairness concern and so on. Numerous behavioral experiments and empirical studies have shown the universal existence of these preferences and then often derived the results which deviate from the conventional normative theory.

Many scholars from the domain of economics and marketing have tried to consider behavioral factors in their studies and have derived many interesting and meaningful conclusions, but incorporating behavioral factors into OM is just at its beginning and a much deeper understanding needs to be further investigated. As an important research area with a prosperous application of OM, the topic of supply chain contracts and its coordination will play a significant role in BOM. We try to incorporate the theory of social preferences into the context of supply chain to study the influences of these behavioral factors on the supply chain's decisions and coordination.

After briefly introducing the background and methods of our research, we reviewed some important theories in detail which are closely related to our research, including supply chain management theory, social preference theory, game theory, and some researches of introducing social preferences to supply chain in the past decades. With regard to supply chain management, we mainly reviewed the classical newsboy model and some related researches and supply chain contracts design and coordination issues; in the part of social preference theory, we mainly reviewed three mainstream social preferences: preference for fairness concern, preference for reciprocity and preference for status seeking; literature review of Game Theory mainly includes three kinds of games: Stackelberg game, Nash bargaining game and psychological game and their related extensions.

After Literature Review, we proceed to the core content of this thesis, including two parts: Chapters 3 and 4. The main innovation of Chapter 3 is that we are the first to incorporate Nash bargaining solution as the fairness concern reference point of decision makers into a simple wholesale-price contract supply chain consisting of one supplier and one retailer in the case of stochastic market for our research; in addition, the two members have the preference for status seeking in this model as well. In Chapter 4, intentions of the decision-makers is introduced as an important factor to the context of supply chain for the first time. We focus on the influences of intentions on both decision-makers and the whole supply chain. In order to simplify the mathematical deduction, we still use a simple wholesale-price contract supply chain model consisting of one supplier and one retailer, but unlike the previous section, the market involved in this part is assumed to be deterministic.

We build two models, fairness-concerned model and reciprocity model within the context of supply chain in Chapter 3 and Chapter 4, respectively. These two models are different, but both of them belong to the fairness models since fair references are both key parts of the two models. Therefore, based on this common, we summarize the main conclusions of this thesis as follows.

1. **The motivation behind the decisions of decision-makers, namely intentions has important influence on supply chain coordination**

In reality and experiments, the researchers found that many phenomena cannot be well explained by the classical theory of fairness, the reason is, in addition to "result oriented" fairness concern, the decision-makers also have motivation-oriented or intention-oriented fairness concerns, then based on the classical theory of fairness, reciprocal theory containing the intention has developed, so intentions are the key factors for the difference between the classical theory of fairness and reciprocity.

The influences of intentions on supply chain coordination can be well showed in the Chapter 4 of this thesis. In this part, there is no intention in the "Harmonious Supply Chain", we only obtain one equilibrium, and this equilibrium cannot coordinate the supply chain; in the "Acrimonious Supply Chain", however, it involves the decision-makers' intentions and in this case we have four pairs of equilibria, and these four equilibria have different features under the influences of intentions. Moreover, the supply chain can be coordinated under one of the equilibria as long as certain parameter conditions are satisfied. It is the effect of intentions that make the improvement in channel efficiency possible.

2. **The degree of behavioral collaboration has important influence on supply chain coordination**

The so-called degree of behavioral collaboration is a new kind of classification for behavioral sociality in this thesis. That is, if a kind of behavior shows more consideration to others and takes care of the interests of others to some extent, then we classify this kind of behavior as relative high degree of collaborative behavior; on the other hand, if a kind of behavior shows more consideration to the decision maker itself, and don't want to share more interests with others, it will be classified as relative low degree of collaborative behavior. The influences of degree of behavioral collaboration on supply chain coordination are shown in Chapters 3 and 4, and also can be found in Cui et al. (2007) which focuses on distributional fairness and Ho and Su (2009) which pays attention to both distributional and peer-induced fairness.

Status-seeking preference studied in Chapter 3 belongs to a relatively low degree of collaborative behavior, because the status-seeking utility shows only disadvantage aversion, which derives the result that the traditional coordinating (noncoordinating) contracts - based on positive affine transformations are still able (unable) to coordinate the fairness-concerned channel, no matter the coordinating goal is to maximize the channel profit or channel utility. Therefore, the wholesale-price contract which cannot coordinate traditional channel is still unable to coordinate the channel in which the preference for status seeking exists. Though incorporating the preference for fairness concern into the supply chain won't change the state of coordination, it increases the difficulty of those coordinating contracts to coordinate the channel.

Reciprocity model studied in Chapter 4 of this thesis belongs to the "relatively high degree of collaborative behavior", which contains the meaning of kindness and reciprocity to others. Consequently, we derived that the wholesale-price contract supply chain can be coordinated in "Acrimonious Supply Chain" situation if certain parameter conditions are satisfied.

3. **The influences of the supplier's and the retailer's behavioral factors on their decisions are obviously different, or even there is a possibility that the retailer's weak position within the context of leader-follower game can be improved due to the introduction of the social preferences**

In Chapter 3, the results show that the influences of the supplier's and the retailer's fairness concerns on their decisions are totally different. The retailer's fairness concern will not affect his own optimal order quantity while the retailer's optimal order quantity is decreasing with the supplier's fairness concern. However, the supplier's wholesale price increases with her own fairness concern, but decreases with the others'.

In Chapter 4, the analysis shows that the influences of the supplier's and the retailer's fairness benchmarks and the impacts of intention factors on the supply chain's decisions are also completely different. Specifically, when the retailer's fairness benchmark is higher, both prices are decreasing, but if the supplier's fairness benchmark increases, the retail price is decreasing while the wholesale price is increasing. Furthermore, as the supplier's intention becomes more obvious, the higher price the retailer charges; but the more obvious intention the retailer has, the lower wholesale price the supplier makes.

4. **The influences of the supplier's and the retailer's behavioral factors on the whole channel efficiency are obviously different**

In Chapter 3, the results show that the influences of supplier's and retailer's fairness concern and bargaining power on the channel's performance are obviously different. As we can see from the analysis of Chapter 3, the impact of the supplier's fairness concern on supply chain efficiency is more obvious than the retailer's, that is because the supplier's sensitivity to fairness may play a relatively more important role in the supply chain performance. Besides, the higher bargaining power the supplier has, the worse performance supply chain will be, but the channel efficiency is increasing with the retailer's bargaining power.

In Chapter 4, our analysis shows that the influences of the supplier's and the retailer's intentions on supply chain performance are different, too. The more obvious intention the supplier has, the worse performance supply chain is, but if the retailer's intention is more obvious, the channel performance becomes better.

5.2 Future Research

This thesis introduces several mainstream kinds of social preferences, such as, fairness concern preference, status-seeking preference and reciprocity preference into the simple wholesale-price contract supply chain, in order to study the influence of these social preferences on decision-makers' decisions and the whole supply chain, especially the influences on supply chain co-ordination and generates some important managerial implications. While we believe that our analysis has derived some significant insights, this thesis also exists the following important limitations which is worthy to give further investigate in the future.

A supplier plays game with a dominant retailer

In this thesis, the supplier possesses more power because of her "first-mover" advantage in Stackelberg game. However, what would be the result when they have the same status. Therefore, incorporating the players's fairness concerns into the dyadic supply chain with dominant retailer would be a rewarding issue.

Extension to more complex supply chain background

Considering the complexity of mathematical model, both Chapters 3 and 4 consider simple wholesale-price contracts within the context of the supply chain consisting of a single supplier and a single retailer. Thus, a question naturally arises: For more complex supply chain background, whether the conclusion of this thesis still be right? Will there be richer conclusions? These could be further investigations. The extension of the background of supply chain can start from the following three aspects:

(1) Consider two fairness concerns simultaneously

“Distributional-fairness concern” exists between the supplier and the retailer while “peer-induced fairness concern” exists among suppliers or retailers. Competitions among suppliers or retailers may reduce fairness concerns between the supplier and the retailer. Therefore, it would be promising to consider the two fairness concerns simultaneously in distributed supply chains or assembly supply chains.

(2) Consider other types of contract

Other types of contracts, including the buyback contract, the revenue-sharing contract, the quantity-flexibility contract, the sales-rebate contract, the quantity-discount contract, can coordinate a dyadic conventional supply chain. Addressing the problem that if they can keep coordinating the behavioral supply chains is significant, because it will help us to design new fairness-concern-based contracts to improve the channel efficiency.

(3) Consider the incomplete information supply chain structures

The effects of information on supply chain is a hot field of supply chain management in the last two decades. The framework of this thesis belongs to complete information structure, that is, all the parameters of our model are the common knowledge. In order to build a model which is more in line with the real situation, we can consider incomplete information structure, such as some important behavioral parameters are unknown, or to consider the situation in which some external information or signals can be received by decision-makers, etc.

More reliable and practicable intention factors

The structures of the intention factors (i.e., θ_r and θ_s) are not rich enough, so it would be interesting to enrich them based on behavioral experiments and empirical studies, but it may be accompanied by more difficulty in calculation.

Consider other individual decision making biases

In addition to the social preferences, other behavioral factors, such as mental accounting, regret theory and framing effects, would be worth to study in the context of supply chain. For example, Wang and Webster (2009) consider a loss-averse manager's decision-making behavior in the single-period newsvendor problem and have some novel findings. They find that the loss-averse newsvendor's optimal order quantity may increase in wholesale price and decrease in retail price, which can never occur in the risk-neutral newsvendor models.

Appendix A

Appendix of Chapter 3

A.1 Proofs of Proposition 3.4-3.5

A.1.1 Proof of Proposition 3.4

Proof. Taking the first derivative of Eq. (3.21) with respect to q, we have

$$\frac{\partial u_s(q,w(q))}{\partial q} = \frac{(1+\lambda_s)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\left[-p\bar{F}(q)g(q)\left(1+(1-\alpha)\lambda_s\right)+\left(p\bar{F}(q)-c\right)\right]$$

The supplier's utility function is unimodal if the above expression is decreasing. In order to demonstrate this, we assume that the support of $F(\cdot)$ is an interval $[\underline{a},\overline{a})$. That is, for $\forall x < \underline{a}$,$F(x)=0$; for $\forall x \geqslant \overline{a}$, $F(x)=1$. Furthermore, $F(\cdot)$ is IGFR distribution, so $g(\cdot)$ is increasing in $[\underline{a},\overline{a})$. Define $\overline{q} = \sup\{q\in[0,\bar{a})|\, g(q)\leqslant 1/\left(1+(1-\alpha)\lambda_s\right)\}$. When $q\in[0,\underline{a})$, $F(q)\equiv 0$, $\bar{F}(q)\equiv 1$, $f(q)=0$, $g(q)=0<1/\left(1+(1-\alpha)\lambda_s\right)$, thus $\overline{q}\geqslant\underline{a}$. Therefore, when $q\in[0,\underline{a})$, $g(q)=0$, $\partial u_s/\partial q = (1+\lambda_s)(p-c)/\left[1+\alpha(\lambda_r-\lambda_s)+\lambda_s\right]>0$, which means u_s is increasing in q in $[0,\underline{a})$. When $q\in[\underline{a},\overline{q}]$, $g(q)\leqslant 1/\left(1+(1-\alpha)\lambda_s\right)$, we have $\partial^2 u_s/\partial q^2<0$, i.e., u_s is concave function with regard to q, and thus u_s has the unique optimal value q_f^* which lies in the interval $[\underline{a},\overline{q}]$ and satisfies $p\bar{F}\left(q_f^*\right)\left[1-\left(1+(1-\alpha)\lambda_s\right)g\left(q_f^*\right)\right]-c=0$. When $q\in(\overline{q},\overline{a})$,$g(q)>1/\left(1+(1-\alpha)\lambda_s\right)$, so $\partial u_s/\partial q<0$ and u_s is decreasing in $(\overline{q},\overline{a})$. When $q\in[\overline{a},+\infty)$, $F(q)\equiv 1$, $\bar{F}(q)\equiv 0$,$f(q)=0$ and $g(q)=0$, thus $\partial u_s/\partial q = -c(1+\lambda_s)/\left[1+\alpha(\lambda_r-\lambda_s)+\lambda_s\right]<0$ and u_s is decreasing in $[\overline{a},+\infty)$. To sum up, u_s has the unique optimal value q_f^* which satisfies Eq. (3.23) and it must fall over the interval $[\underline{a},\overline{q}]$. Consequently, any solution q_f^* to Eq. (3.23) is unique and must lie in set $\{q|\left[1-\left(1+(1-\alpha)\lambda_s\right)g(q)\right]\geq 0, q\geq 0\}$. Since $\bar{F}(q)$ is decreasing in

q and is always non-negative, u_s is decreasing in q because the term $[1-(1+(1-\alpha)\lambda_s)g(q)]$ is always non-negative and decreasing in q as well. Therefore, the unique quantity q_f^* sold to the retailer at the optimal wholesale price $w_f^* = w(q_f^*)$ that maximizes the supplier's utility can be given by

$$p\bar{F}(q_f^*)\left[1-g(q_f^*)(1+(1-\alpha)\lambda_s)\right] = c$$

Then, substituting Eq. (3.20) into above expression yields Eq. (3.22). □

A.1.2 Proof of Proposition 3.5

Proof. By the implicit function theorem, we have

$$\frac{\partial q_f^*}{\partial \lambda_r} = 0$$

$$\frac{\partial q_f^*}{\partial \lambda_s} = \frac{-p\bar{F}(q_f^*)g(q_f^*)(1-\alpha)}{pf(q_f^*)\left[1-g(q_f^*)(1+(1-\alpha)\lambda_s)\right]+p\bar{F}(q_f^*)(1+(1-\alpha)\lambda_s)g'(q_f^*)} < 0$$

After taking the first derivative of Eq. (3.22) with respect to λ_r and λ_s respectively, we derive:

$$\frac{\partial w_f^*}{\partial \lambda_r} = \frac{\alpha(1-\alpha\lambda_s+\lambda_s)\left[c-p\bar{F}(q_f^*)\right]}{(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)^2} < 0$$

$$\frac{\partial w_f^*}{\partial \lambda_s} = \frac{\left\{\begin{array}{l} p\left[(1-\alpha)\bar{F}(q_f^*)+(1+\lambda_s(1-\alpha))\frac{\partial \bar{F}(q_f^*)}{\partial \lambda_s}\right](1+\alpha(\lambda_r-\lambda_s)+\lambda_s) \\ +\alpha\left[(1+\lambda_s(1-\alpha))p\bar{F}(q_f^*)+\alpha\lambda_r c\right] \end{array}\right\}}{(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)^2} > 0$$

□

A.2 Profit Allocation and Supply Chain Efficiency

The cumulative distribution function is $F(q) = q^k, k>0, q\in[0,1]$. Thus, $qf(q) = kq^k$; $S(q) = q - q^{k+1}/(k+1)$. By Eqs. (3.22) and (3.23), we get:

$$q_f^* = \left[\frac{p-c}{p[1+k(1+(1-\alpha)\lambda_s)]}\right]^{\frac{1}{k}}$$

$$w_f^* = \frac{(1+\lambda_s-\alpha\lambda_s)\,p\bar{F}(q_f^*)+\alpha\lambda_r c}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}$$

The supplier's and the total channel's profits of fairness-concerned supply chain are:

$$\pi_s(q_f^*, w_f^*) = \frac{k(p-c)(1+\lambda_s-\alpha\lambda_s)^2\left(\frac{p-c}{p(1+k(1+\lambda_s-\alpha\lambda_s))}\right)^{\frac{1}{k}}}{(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)\,(1+k\,(1+(1-\alpha)\lambda_s))}$$

$$\pi(q_f^*) = \frac{k(p-c)\,(2+k+(1+k)(1-\alpha)\lambda_s)\left(\frac{p-c}{p(1+k(1+\lambda_s-\alpha\lambda_s))}\right)^{\frac{1}{k}}}{(1+k)\,(1+k\,(1+(1-\alpha)\lambda_s))}$$

The supplier's profit share ζ is:

$$\zeta \equiv \frac{\pi_s\left(q_f^*, w_f^*\right)}{\pi\left(q_f^*\right)} = \frac{(1+k)(1+\lambda_s-\alpha\lambda_s)^2}{(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)\,[2+k+(1+k)(1-\alpha)\lambda_s]}$$

The channel's maximized profit of fairness-neutral supply chain is:

$$\pi\,(q^o) = \frac{k}{k+1}p(q^o)^{k+1}$$

The efficiency of the contract δ is:

$$\delta \equiv \frac{\pi\left(q_f^*\right)}{\pi\,(q^o)} = \left[\frac{1}{1+k\,(1+(1-\alpha)\lambda_s)}\right]^{1+\frac{1}{k}}[2+k+(1+k)(1-\alpha)\lambda_s]$$

The supplier's share of the supply chain's optimal profit η is:

$$\eta \equiv \frac{\pi_s\left(q_f^*, w_f^*\right)}{\pi\,(q^o)} = \left[\frac{1}{1+k\,(1+(1-\alpha)\lambda_s)}\right]^{1+\frac{1}{k}}\frac{(1+\lambda_s-\alpha\lambda_s)^2(k+1)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}$$

A.3 Proof of Theorem 3.1

Theorem 3.1 is equivalent to saying that, through positive affine transformations, a contract which is able to coordinating a fairness-neutral channel can also coordinate a channel with fairness concern.

If a contract can coordinate the traditional channel (fairness-neutral channel) by a positive affine transformations, the retailer's profit have the following linear relation; i.e., $\pi_r = m\pi + n$, where m and n are constants, $m > 0$. The retailer's and the supplier's utilities of the same supply chain but with fairness concerns are

$$\begin{cases} u_r = (1+\lambda_r)\pi_r - \frac{\alpha\lambda_r(1+\lambda_r)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\pi \\ \quad = (1+\lambda_r)\left[m - \frac{\alpha\lambda_r}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right]\pi + (1+\lambda_r)n \\ u_s = \pi_s + \lambda_s\left(\pi_s - \frac{(1-\alpha)(1+\lambda_s)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\pi\right) \\ \quad = (1+\lambda_s)\left[(1-m) - \frac{\lambda_s(1-\alpha)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right]\pi - (1+\lambda_s)n \end{cases}$$

Let $A = (1+\lambda_r)[m-(\alpha\lambda_r)/(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)]$, $B = (1+\lambda_r)n$, We have $u_r = A\pi + B$; let $C = (1+\lambda_s)[(1-m)-(\lambda_s(1-\alpha))/(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)]$, $D = -(1+\lambda_s)n$, we get $u_s = C\pi + D$. λ_r and λ_s are constants since they are extrinsic parameters here. Hence, A,B,C and D are also constants.

If the goal of coordination is to maximize the channel's profit, the above analysis implies that the retailer's utility has a positive affine relationship with the whole channel's profit, that is, those contracts that coordinate the fairness-neutral supply chain can also coordinate the same supply chain but with fairness concerns if $A > 0$. By algebraic operations, the constraint that they have positive affine relationship is $m > (\alpha\lambda_r)/(1+\alpha(\lambda_r-\lambda_s)+\lambda_s)$.

Because $u_r = A\pi + B, u_s = C\pi + D$, we have $u = (A+C)\pi + (B+D)$. After transforming the above expression, we get $\pi = u/(A+C) - (B+D)/(A+C)$. Then,

$$\begin{cases} u_r = A\pi + B = \frac{A}{A+C}u + \frac{BC-AD}{A+C}; \\ u_s = C\pi + D = \frac{C}{A+C}u + \frac{AD-BC}{A+C}. \end{cases}$$

Therefore, if the goal of coordination is to maximize the channel's utility, the above analysis indicates that the retailer's utility has a positive affine relationship with the whole channel's utility, which means those contracts that coordinate the fairness-neutral supply chain can also coordinate the fairness-concerned supply chain if $A/(A+C) > 0$, i.e.

$$m \in \begin{cases} \left(\frac{\alpha\lambda_r}{1+\alpha\lambda_r+\lambda_s-\alpha\lambda_s}, \frac{1}{-\lambda_r+\lambda_s} + \frac{\alpha(1+\lambda_r)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right), \lambda_r < \lambda_s \\ \left(\frac{\alpha\lambda_r}{1+\lambda_r}, +\infty\right), \lambda_r = \lambda_s \\ \left(0, \frac{1}{-\lambda_r+\lambda_s} + \frac{\alpha(1+\lambda_r)}{1+\alpha(\lambda_r-\lambda_s)+\lambda_s}\right) \cup \left(\frac{\alpha\lambda_r}{1+\alpha\lambda_r+\lambda_s-\alpha\lambda_s}, +\infty\right), \lambda_r > \lambda_s \end{cases}$$

To sum up, no matter whether the coordination consists of maximizing the whole channel's profit or utility, incorporating fairness concerns into the supply chain does not change the channel's status of coordination when the above constraints are satisfied.

Appendix B

Appendix of Chapter 4

B.1 Proof of the optimal price for the retailer

B.1.1 RH1: Unambiguous Kindness

The first-order condition with regard to p in Eq. (10) is

$$a - bp - b(p-w) - b\rho_r(w-c)(a-bp'')\left[(p''-w) - \gamma(w-c)\right] = 0.$$

We have already explained in previous parts that the belief equals the practical activity in equilibrium, i.e., $p = p''$. Thus, we get following two possible prices

$$p^- = \frac{\left\{\begin{aligned} &\rho_r(w-c)\left[a+b((1+\gamma)w-\gamma c)\right]+2- \\ &\sqrt{(\rho_r)^2(w-c)^2(a-b((1+\gamma)w-\gamma c))^2+4b\gamma\rho_r(w-c)^2+4}\end{aligned}\right\}}{2b\rho_r(w-c)}$$

$$p^+ = \frac{\left\{\begin{aligned} &\rho_r(w-c)\left[a+b((1+\gamma)w-\gamma c)\right]+2+ \\ &\sqrt{(\rho_r)^2(w-c)^2(a-b((1+\gamma)w-\gamma c))^2+4b\gamma\rho_r(w-c)^2+4}\end{aligned}\right\}}{2b\rho_r(w-c)}$$

The price p^+ should be deleted since it is greater than $\frac{a}{b}$. Additionally, the second derivative regarding p in Eq. (10) is $-2b$, so the unique price p^- may be able to maximize the retailer's utility. Furthermore, it is not difficult for us to derive $w < p^- < \frac{a}{b}$ by algebraic operation. Therefore, p^- is the optimal retail price.

B.1.2 RC1: Unambiguous Unkindness

Before we start demonstrating the optimal retail price of RC1, we would like to provide two important results first.

Result 1: $p^- \geqslant \frac{(\mu+1)w-c}{\mu} \Leftrightarrow c < w \leqslant w_{\rho r}$.

Result 2: $p^- \geqslant (\gamma+1)w - \gamma c \Leftrightarrow c < w \leqslant \frac{a+2b\gamma c}{b(2\gamma+1)}$.

We prove the two important results as follows.

Proof. The following is the proof of result 1.

Let

$$
\begin{aligned}
&Z(w) = \rho_r(w-c)\left\{\mu\left[a-bw\right]+b(w-c)(\mu\gamma-2)\right\}+2\mu \\
&= w^2\rho_r b\left[(\mu\gamma-2)-\mu\right]+w\rho_r\left[(a+bc)\mu-2bc(\mu\gamma-2)\right]-ca\mu\rho_r+c^2\rho_r b(\mu\gamma-2)+2\mu
\end{aligned}
$$

$Z(w)$ is a quadratic equation with regard to w. If $\gamma\mu > \mu+2$, it is a convex function; if $1 < \gamma\mu < \mu+2$, it is a concave function; if $\gamma\mu = \mu+2$, it degenerates into a simple equation $\rho_r\mu(w-c)(a-bc)+2\mu$, which must be positive. As can be seen from the above analysis, $Z(w)$ is a very important equation. We have to find the requirements for $Z(w) > 0$ first. Two cases are discussed below:(A)$Z(w)$ has no real root; (B)$Z(w)$ has two real roots (they could be equal).

(A) $\gamma\mu > 2+\mu+\frac{(a-bc)^2\mu^2\rho_r}{8b\mu}$. The quadratic equation $Z(w)$ is convex and has no real root, so $\rho_r(w-c)\left\{\mu\left[a-bw\right]+b(w-c)(\mu\gamma-2)\right\}+2\mu > 0$. Therefore, after some calculation, by $p^- > \frac{(\mu+1)w-c}{\mu}$, we derive

$$
\rho_r b(\mu\gamma-1)(w-c)^2\left\{\mu(a-bw)-b(w-c)\right\} > \mu\left[2b(w-c)-\mu(a-bw)\right] \tag{B.1}
$$

That is, if the condition B.1 be satisfied, we have $p^- > \frac{(\mu+1)w-c}{\mu}$.

(B) $1 < \gamma\mu \leqslant 2+\mu+\frac{(a-bc)^2\mu^2\rho_r}{8b\mu}$. The quadratic equation has two real roots as follows:

$$
\begin{aligned}
w_{c_2}^- &= \frac{\left[a\mu+bc(4+\mu-2\gamma\mu)\right]\sqrt{\rho_r}-\sqrt{8b\mu(2+\mu-\gamma\mu)+(a-bc)^2\mu^2\rho_r}}{2b(2+\mu-\gamma\mu)\sqrt{\rho_r}} \\
w_{c_2}^+ &= \frac{\left[a\mu+bc(4+\mu-2\gamma\mu)\right]\sqrt{\rho_r}+\sqrt{8b\mu(2+\mu-\gamma\mu)+(a-bc)^2\mu^2\rho_r}}{2b(2+\mu-\gamma\mu)\sqrt{\rho_r}}
\end{aligned}
$$

After some algebraic manipulation, we find that $w_{c_2}^- < c$ always holds.

(a) When $1 \leqslant 2 - \frac{2b\mu}{\rho_r(a-bc)^2}$.

If $1 < \gamma\mu < 2 - \frac{2b\mu}{\rho_r(a-bc)^2}$, we have $c < w_{c_2}^+ < \frac{a}{b}$. In the following part, we will discuss several scenarios when the quadratic equation has two real roots.

(i) $1 < \gamma\mu < 2 - \frac{2b\mu}{\rho_r(a-bc)^2}$.

In this scenario, $\rho_r > \frac{2b\mu}{(a-bc)^2(2-\gamma\mu)}$, which guarantees that $c < w_{c_2}^+ < \frac{a}{b}$. Function Z is concave with regard to w. There are two possibilities [1]: (i) if $w \leqslant w_{c_2}^+$, then $Z(w) \geqslant 0$; (ii) if $w > w_{c_2}^+$, then $Z(w) < 0$.

(ii) $2 - \frac{2b\mu}{\rho_r(a-bc)^2} \leqslant \gamma\mu \leqslant 2 + \mu$.

In this scenario, $\rho_r \leqslant \frac{2b\mu}{(a-bc)^2(2-\gamma\mu)}$, which means $\frac{a}{b} \leqslant w_{c_2}^+$. The function $Z(w)$ is concave with regard to w. For all $w \in (c, \frac{a}{b})$, $Z(w) > 0$.

(iii) $2 + \mu < \gamma\mu < 2 + \mu + \frac{(a-bc)^2\mu^2\rho_r}{8b\mu}$.

This scenario means $w_{c_2}^+ < c$. Furthermore, the function $Z(w)$ is convex with regard to w. Accordingly, for $\forall w \in (c, \frac{a}{b})$, $Z(w) > 0$.

(b) When $1 > 2 - \frac{2b\mu}{\rho_r(a-bc)^2}$.

(i) $1 < \gamma\mu \leqslant 2 + \mu$.

In this scenario, $\rho_r \leqslant \frac{2b\mu}{(a-bc)^2(2-\gamma\mu)}$, which means $\frac{a}{b} \leqslant w_{c_2}^+$. The function $Z(w)$ is concave with regard to w. For all $w \in (c, \frac{a}{b})$, $Z(w) > 0$.

(ii) $2 + \mu < \gamma\mu < 2 + \mu + \frac{(a-bc)^2\mu^2\rho_r}{8b\mu}$.

This scenario means $w_{c_2}^+ < c$. Furthermore, the function $Z(w)$ is convex with regard to w. Accordingly, for $\forall w \in (c, \frac{a}{b})$, $Z(w) > 0$.

These results for conditions (A) and (B) can be summarized as

(I) if $1 < \gamma\mu \leqslant \max\left(1, 2 - \frac{2b\mu}{\rho_r(a-bc)^2}\right)$, we have $p^- > \frac{(\mu+1)w-c}{\mu} \Leftrightarrow w_{\rho r}^+ \cap \left\{w \leqslant w_{c2}^+\right\}$;

(II)if $\gamma\mu > \max\left(1, 2 - \frac{2b\mu}{\rho_r(a-bc)^2}\right)$, we derive $p^- > \frac{(\mu+1)w-c}{\mu} \Leftrightarrow w_{\rho r}^+$.

where $w_{\rho r}^-$ and $w_{\rho r}^+$ denote two complementary conditions defined respectively as follows.

$$
\begin{aligned}
w_{\rho r}^- &= \left\{\rho_r b(\mu\gamma - 1)(w-c)^2\left[\mu(a-bw) - b(w-c)\right] \leqslant \mu\left[2b(w-c) - \mu(a-bw)\right]\right\} \\
w_{\rho r}^+ &= \left\{\rho_r b(\mu\gamma - 1)(w-c)^2\left[\mu(a-bw) - b(w-c)\right] > \mu\left[2b(w-c) - \mu(a-bw)\right]\right\}
\end{aligned}
$$

[1] What we need is to find the conditions for $Z(w) \geqslant 0$ or $Z(w) < 0$. After that, it is not difficult to get the optimal retail price for the retailer. At the end of this subsection, we will review all the possibilities and for each possibility, the optimal retail price will be given.

Define

$$f_{\rho_r}(w) = \rho_r(w-c)^2\left[\mu(a-bw)-b(w-c)\right]b(\mu\gamma-1)-\mu\left[2b(w-c)-\mu(a-bw)\right]$$

With the help of the software MATHEMATICA, we find that the equation $f_{\rho_r}(w)=0$ has one real root and two pairs of complex roots. Let the real root be w_{ρ_r}, then $f_{\rho_r}(w)$ can be expressed by $f_{\rho_r}(w)=\left(w-w_{\rho_r}\right)\left(Aw^2+Bw+C\right)$, where $A<0$, Aw^2+Bw+C is a quadratic function of w and doesn't have real root. Thus, $Aw^2+Bw+C<0$ and curve $f_{\rho_r}(w)$ has only one point of intersection with x-axis. Accordingly, $f_{\rho_r}(w)>0 \Leftrightarrow w<w_{\rho_r}$, which means $w_{\rho r}^{+} \Leftrightarrow w<w_{\rho_r}$ and $w_{\rho r}^{-} \Leftrightarrow w>w_{\rho_r}$. Besides, we also have $f_{\rho r}(c)>0$, $f_{\rho r}\left(\frac{a\mu+bc}{b(\mu+1)}\right)<0$, thus, $c<w_{\rho r}<\frac{a\mu+bc}{b(\mu+1)}$. Furthermore, it is not difficult for us to demonstrate that $w_{c2}^{+}>\frac{a\mu+bc}{b(\mu+1)}$ when $1<\gamma\mu\leqslant 2-\frac{2b\mu}{\rho_r(a-bc)^2}$, which means $w_{\rho r}^{+}\cap\left\{w|w\leqslant w_{c2}^{+}\right\}=w_{\rho r}^{+}=\left\{w|w<w_{\rho r}\right\}$. Therefore, (I) and (II) can be combined as result 1. □

Proof. The following is the proof of result 2.

Because

$$\begin{aligned}
&p^- > (\gamma+1)w-\gamma c\\
&\Leftrightarrow \rho_r(w-c)\left(a-b\left((\gamma+1)w-\gamma c\right)\right)+2\\
&> \sqrt{\rho_r^2(w-c)^2\left(a-b\left((\gamma+1)w-\gamma c\right)\right)^2+4b\gamma\rho_r(w-c)^2+4},
\end{aligned}$$

if $\rho_r(w-c)\left(a-b\left((\gamma+1)w-\gamma c\right)\right)+2\geqslant 0$, then we have $p^->(\gamma+1)w-\gamma c \Leftrightarrow c<w<\frac{a+2b\gamma c}{(2\gamma+1)b}$. Accordingly,

$$p^- > (\gamma+1)w-\gamma c \Leftrightarrow \begin{cases} \rho_r(w-c)\left(a-b\left[(\gamma+1)w-\gamma c\right]\right)+2\geqslant 0\\ c<w<\frac{a+2b\gamma c}{(2\gamma+1)b}\end{cases}$$

Define $f_\gamma(w)=\rho_r(w-c)\left(a-b\left((\gamma+1)w-\gamma c\right)\right)+2$. It is a quadratic function with regard to w and the parameter of quadratic term is $-b\rho_r(1+\gamma)<0$, that is, equation $f_\gamma(w)=0$ has one negative real root and one positive real root and they are represented by w_{r_1} and w_{r_s} respectively, i.e., $w_{r_1}<w_{r_2}$. Thus, we have $f_\gamma(w)=-b\rho_r(1+\gamma)(w-w_{r_1})(w-w_{r_2})$, which means $f_\gamma(w)\geqslant$

$0 \Leftrightarrow (w - w_{r_1})(w - w_{r_2}) \leqslant 0 \Leftrightarrow w_{r_1} \leqslant w \leqslant w_{r_2}$. Therefore,

$$p^- > (\gamma+1)w - \gamma c \Leftrightarrow \begin{cases} w_{r_1} \leqslant w \leqslant w_{r_2} \\ c < w < \frac{a+2b\gamma c}{(2\gamma+1)b} \end{cases}$$

Furthermore, we have

$$f_\gamma(c) = 2 > 0 \Rightarrow w_{r_1} < c < w_{r_2}$$

$$f_\gamma\left(\frac{a+2b\gamma c}{(2\gamma+1)b}\right) = 2 + \frac{(a-bc)^2\gamma\rho_r}{b(1+2\gamma)^2} > 0 \Rightarrow w_{r_1} < \frac{a+2b\gamma c}{(2\gamma+1)b} < w_{r_2}$$

Thus, $w_{r_1} < c < \frac{a+2b\gamma c}{(2\gamma+1)b} < w_{r_2}$. Consequently, $p^- > (\gamma+1)w - \gamma c \Leftrightarrow c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$. □

In fact, RC1 has the same utility function as that of RH1 except for the difference of constraints. Therefore, p^- is the only possible optimal solution. We also need to test if it satisfies the constraints. Additionally, we are not sure if a/b is smaller than $\frac{(\mu+1)w-c}{\mu}$ or greater than $(\gamma+1)w - \gamma c$ [2]. Thus, we can discuss the following three scenarios.

(1) If $\frac{(\mu+1)w-c}{\mu} \geqslant \frac{a}{b}$, that is $w \geqslant \frac{a\mu+bc}{b(\mu+1)}$, the constraint reduces to $w < p < \frac{a}{b}$. Obviously, the optimal retail price will be the same as that of RH1, i.e., $p_{c_1} = p^-$.

(2) If $\frac{(\mu+1)w-c}{\mu} < \frac{a}{b} \leqslant (\gamma+1)w - \gamma c$, or equivalently $\frac{a+b\gamma c}{b(\gamma+1)} \leqslant w < \frac{a\mu+bc}{b(\mu+1)}$, the constraint becomes $w < p < \frac{(\mu+1)w-c}{\mu}$. Therefore, if $p^- \leqslant \frac{(\mu+1)w-c}{\mu}$, the optimal retail price is p^-; if $p^- > \frac{(\mu+1)w-c}{\mu}$, the optimal retail price will be $\frac{(\mu+1)w-c}{\mu}$. According to result 1, we have: when $c < w \leqslant w_{\rho_r}$, $p^- \geqslant \frac{(\mu+1)w-c}{\mu}$, so $p_{c_1} = \frac{(\mu+1)w-c}{\mu}$; when $w > w_{\rho_r}$, $p^- < \frac{(\mu+1)w-c}{\mu}$, so $p_{c_1} = p^-$. In conclusion, we have

$$p_{c_1} = \begin{cases} \frac{(\mu+1)w-c}{\mu}, c < w \leqslant w_{\rho r} \\ p^-, w_{\rho r} < w \end{cases}$$

(3) If $(\gamma+1)w - \gamma c < \frac{a}{b}$, or equivalently $w < \frac{a+b\gamma c}{b(\gamma+1)}$, the constraint turns into $w < p < \frac{(\mu+1)w-c}{\mu}$ or $p > (\gamma+1)w - \gamma c$. Besides, we have $p_{c_1} = p^-$ if $p^- < \frac{(\mu+1)w-c}{\mu}$ or $p^- > (\gamma+1)w - \gamma c$. According to result 1 and result 2, $p^- < \frac{(\mu+1)w-c}{\mu} \Leftrightarrow w > w_{\rho_r}$ and $p^- > (\gamma+1)w - \gamma c \Leftrightarrow c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$. Besides, $f_{\rho_r}\left(\frac{a+2b\gamma c}{b(2\gamma+1)}\right) > 0$ means that $\frac{a+2b\gamma c}{b(2\gamma+1)} < w_{\rho r}$. Therefore, the condition for $p_{c_1} = p^-$ becomes $c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$ or $w > w_{\rho_r}$.

When $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w \leqslant w_{\rho r}$, we have $\frac{(\mu+1)w-c}{\mu} \leqslant p^- \leqslant (\gamma+1)w - \gamma c$. Said differently, in the

[2] $\frac{(\mu+1)w-c}{\mu} < (\gamma+1)w - \gamma c$ always holds since the prerequisite of RC1 is $\gamma\mu > 1$.

interval of $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w \leqslant w_{\rho r}$, the optimal retail price is $\frac{(\mu+1)w-c}{\mu}$ or $(\gamma+1)w-\gamma c$, and the one by which the retailer obtains more utility is the optimal retail price. Recall that the retailer's utility function is $U_r = (p-w)(a-bp)+\rho_r(a-bp'')(w-c)b\left[p''-((\gamma+1)w-\gamma c)\right](p''-p)$. However, we know that $p''=p$ only if the game achieves equilibrium. That is to say, the retailer will substitute $\frac{(\mu+1)w-c}{\mu}$ and $(\gamma+1)w-\gamma c$ into the utility function $U_r=(p-w)(a-bp)$ [3] to see which utility is greater.

Therefore, we can easily know that the optimal retail price is $(\gamma+1)w-\gamma c$ when $w \leqslant \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)}$ and $\frac{(\mu+1)w-c}{\mu}$ when $w > \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)}$.

Up to this point, we have discussed (1), (2), and (3) of RC1. We conclude the results as follows.

1) The condition for $p_{c_1}=(\gamma+1)w-\gamma c$ is

$$\left\{w \,\middle|\, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)}\right\} \cap \left\{w \,\middle|\, w < \frac{a+b\gamma c}{b(\gamma+1)}\right\}$$

2) The condition for $p_{c_1}=\frac{(\mu+1)w-c}{\mu}$ is

$$\begin{gathered}\left(\left\{w \,\middle|\, w \leqslant w_{\rho_r}\right\} \cap \left\{w \,\middle|\, \frac{a+b\gamma c}{b(\gamma+1)} \leqslant w < \frac{a\mu+bc}{b(\mu+1)}\right\}\right)\\ \cup\left(\left\{w \,\middle|\, \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \leqslant w \leqslant w_{\rho_r}\right\} \cap \left\{w \,\middle|\, w < \frac{a+b\gamma c}{b(\gamma+1)}\right\}\right)\end{gathered}$$

3) The condition for $p_{c_1}=p^-$ is

$$\begin{gathered}\left\{w \,\middle|\, w \geqslant \frac{a\mu+bc}{b(\mu+1)}\right\} \cup \left(\left\{w \,\middle|\, w > w_{\rho r}\right\} \cap \left\{w \,\middle|\, \frac{a+b\gamma c}{b(\gamma+1)} \leqslant w < \frac{a\mu+bc}{b(\mu+1)}\right\}\right)\\ \cup\left(\left\{w \,\middle|\, w < \frac{a+2b\gamma c}{b(2\gamma+1)} \;\; or \;\; w > w_{\rho_r}\right\} \cap \left\{w \,\middle|\, w < \frac{a+b\gamma c}{b(\gamma+1)}\right\}\right)\end{gathered}$$

According to the discussion above, we have the following two important relationships:

$$c < \frac{a+2b\gamma c}{b(2\gamma+1)} < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} < w_{\rho_r} < \frac{a\mu+bc}{b(\mu+1)} < \frac{a}{b} \; ; \; \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} < \frac{a+b\gamma c}{b(\gamma+1)} < \frac{a\mu+bc}{b(\mu+1)}$$

However, we still don't know the relationship between $\frac{a+b\gamma c}{b(\gamma+1)}$ and w_{ρ_r}. Therefore, result 3 is given below.

Result 3: $\frac{a+b\gamma c}{b(\gamma+1)} \leqslant w_{\rho_r} \Leftrightarrow \gamma\mu \geqslant 1+x_{\gamma\mu}$, where $x_{\gamma\mu}$ is the positive real root of equation $b(1+\gamma)^2\mu(x-1)+(a-bc)^2x^2\rho_r=0$.

Proof. The following is the proof of result 3.

[3] some one may say that this utility function is the same as tradition profit function. Yes, that is true. The reason is that $p''=p$ is the necessary condition of getting the optimal retail price.

Because

$$f_{\rho_r}\left(\frac{a+b\gamma c}{b(\gamma+1)}\right) > 0 \Leftrightarrow \frac{a+b\gamma c}{b(\gamma+1)} < w_{\rho_r}$$
$$\Leftrightarrow b(1+\gamma)^2\mu(\gamma\mu-2)+(a-bc)^2(\gamma\mu-1)^2\rho_r > 0$$

Let $x=\gamma\mu-1$, so $x>0$. Consider $b(1+\gamma)^2\mu(x-1)+(a-bc)^2x^2\rho_r=0$,an equation with regard to x, it has two roots, one is positive and the other is negative. If the positive root is $x_{\gamma\mu}$, then $\frac{a+b\gamma c}{b(\gamma+1)} < w_{\rho_r} \Leftrightarrow \gamma\mu > 1+x_{\gamma\mu}$. □

In summary,

(I) if $1<\gamma\mu<1+x_{\gamma\mu}$, we have $c<\frac{a+2b\gamma c}{b(2\gamma+1)}<\frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)}<w_{\rho_r}<\frac{a+b\gamma c}{b(\gamma+1)}<\frac{a\mu+bc}{b(\mu+1)}<\frac{a}{b}$, thus, the optimal retail price of RC1 is

$$p_{c_1}=\begin{cases} p^-, c<w<\frac{a+2b\gamma c}{b(2\gamma+1)} \;\; or \;\; w_{\rho_r}<w<\frac{a}{b} \\ (\gamma+1)w-\gamma c, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \\ \frac{(\mu+1)w-c}{\mu}, \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \leqslant w \leqslant w_{\rho_r} \end{cases}$$

(II) if $\gamma\mu \geqslant 1+x_{\gamma\mu}$, we have $c<\frac{a+2b\gamma c}{b(2\gamma+1)}<\frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)}<\frac{a+b\gamma c}{b(\gamma+1)}\leqslant w_{\rho_r}<\frac{a\mu+bc}{b(\mu+1)}<\frac{a}{b}$, thus, the optimal retail price of RC1 is

$$p_{c_1}=\begin{cases} p^-, c<w<\frac{a+2b\gamma c}{b(2\gamma+1)} \;\; or \;\; w_{\rho_r}<w<\frac{a}{b} \\ (\gamma+1)w-\gamma c, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \\ \frac{(\mu+1)w-c}{\mu}, \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \leqslant w \leqslant w_{\rho_r} \end{cases}$$

Therefore, we can conclude the results of RC1 as follows:

$$p_{c_1}=\begin{cases} p^-, c<w<\frac{a+2b\gamma c}{b(2\gamma+1)} \;\; or \;\; w_{\rho_r}<w<\frac{a}{b} \\ (\gamma+1)w-\gamma c, \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w < \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \\ \frac{(\mu+1)w-c}{\mu}, \frac{a\mu+bc(\gamma\mu+1)}{b(\gamma\mu+\mu+1)} \leqslant w \leqslant w_{\rho_r} \end{cases}$$

B.1.3 RC2: Ambiguous Unkindness

Likewise, before we start demonstrating the optimal retail price, two important results are given as follows:

Result 4: $p^-_{\xi_r} \geqslant \frac{(\mu+1)w-c}{\mu} \Leftrightarrow c<w\leqslant w_{\rho\xi_r}$.

Result 5: $p^-_{\xi_r} \geqslant (\gamma+1)w-\gamma c \Leftrightarrow c<w\leqslant \frac{a+2b\gamma c}{b(2\gamma+1)}$.

Under this condition, the utility function is similar to that of previous several conditions. Therefore, $p^{-}_{\xi_r}$ is the only possible optimal solution. It is also necessary to test if this solution satisfies the constraint condition, which makes the proof more complicated for this condition. There are the following three possibilities and we have to discuss them independently. (1) $w < \frac{(\mu+1)w-c}{\mu} < (\gamma+1)w-\gamma c < \frac{a}{b}$; (2) $w < \frac{(\mu+1)w-c}{\mu} < \frac{a}{b} \leqslant (\gamma+1)w-\gamma c$; (3) $w < \frac{a}{b} \leqslant \frac{(\mu+1)w-c}{\mu} < (\gamma+1)w-\gamma c$.

Now we will discuss them in detail.

(1) $w < \frac{(\mu+1)w-c}{\mu} < (\gamma+1)w-\gamma c < \frac{a}{b}$. This constraint means that $c < w < \frac{a+b\gamma c}{b(\gamma+1)}$ and the original constraint condition is still $\frac{(\mu+1)w-c}{\mu} < p < (\gamma+1)w-\gamma c$.

(a) when $p^{-}_{\xi_r} \leqslant \frac{(\mu+1)w-c}{\mu}$, according to result 4, $w \geqslant w_{\rho\xi_r}$. Thus, the optimal retail price $p_{c_2} = \frac{(\mu+1)w-c}{\mu}$.

(b) when $p^{-}_{\xi_r} \geqslant (\gamma+1)w-\gamma c$, according to result 5, $w \leqslant \frac{a+2b\gamma c}{b(2\gamma+1)}$. Thus, the optimal retail price $p_{c_2} = (\gamma+1)w-\gamma c$.

Therefore, the optimal retail price for (1) is

$$p_{c_2} = \begin{cases} (\gamma+1)w-\gamma c,\ w \leqslant \frac{a+2b\gamma c}{b(2\gamma+1)} \\ \frac{(\mu+1)w-c}{\mu}, w \geqslant w_{\rho\xi_r} \\ p^{-}_{\xi_r}, \frac{a+2b\gamma c}{b(2\gamma+1)} < w < w_{\rho\xi_r} \end{cases}$$

(2) $w < \frac{(\mu+1)w-c}{\mu} < \frac{a}{b} \leqslant (\gamma+1)w-\gamma c$. This condition equals $\frac{a+b\gamma c}{b(\gamma+1)} \leqslant w < \frac{a\mu+bc}{b(\mu+1)}$ and the original constraint condition becomes $\frac{(\mu+1)w-c}{\mu} < p < \frac{a}{b}$. According to result 4, we have $w \geqslant w_{\rho\xi_r}$ if $p^{-}_{\xi_r} \leqslant \frac{(\mu+1)w-c}{\mu}$ and the optimal retail price is $p_{c_2} = \frac{(\mu+1)w-c}{\mu}$. Therefore, the optimal retail price for (2) will be

$$p_{c_2} = \begin{cases} \frac{(\mu+1)w-c}{\mu}, w \geqslant w_{\rho\xi_r} \\ p^{-}_{\xi_r}, w < w_{\rho\xi_r} \end{cases}$$

(3) $w < \frac{a}{b} \leqslant \frac{(\mu+1)w-c}{\mu} < (\gamma+1)w-\gamma c$. This condition equals $w \geqslant \frac{a\mu+bc}{b(\mu+1)}$. There is no optimal retail price under this condition since the only possible solution $p^{-}_{\xi_r}$ satisfies $w < p^{-}_{\xi_r} < \frac{a}{b}$.

Therefore, the optimal retail price for RC2 will be

$$p_{c_2}=\begin{cases}(\gamma+1)w-\gamma c, c<w\leqslant\frac{a+2b\gamma c}{b(2\gamma+1)}\\ p^-_{\xi_r},\frac{a+2b\gamma c}{b(2\gamma+1)}<w<w_{\rho\xi_r}\\ \frac{(\mu+1)w-c}{\mu},w_{\rho\xi_r}\leqslant w<\frac{a\mu+bc}{b(\mu+1)}\\ \frac{a}{b},\frac{a\mu+bc}{b(\mu+1)}\leqslant w<\frac{a}{b}\end{cases}$$

□

B.2 Proof for the traditional supplier's decision

B.2.1 The traditional supplier's decisions of the acrimonious channel

In fact, there are three local optimal retail prices for the retailer when $\gamma\mu>1$. We use these to help the retailer to choose the globally optimal retail price. If $\gamma\mu>1$, when the supplier charges a wholesale price w, the retailer will choose $p(w)$ as in Eq. (20).

Case 1: If the retailer chooses a wholesale price from intervals $c<w<\frac{a+2b\gamma c}{b(2\gamma+1)}$ or $w_{\rho r}\leqslant w<\frac{a}{b}$, the supplier's optimization problem will be

$$\max_{w}\quad(w-c)(a-bp)\tag{B.2}$$

$$s.t.\begin{cases}p=p^-\\ c<w<\dfrac{a+2b\gamma c}{b(2\gamma+1)}\ \ or\ \ w_{\rho_r}\leqslant w<\dfrac{a}{b}\end{cases}\tag{B.3}$$

The derivative of π_s with regard to w is $\frac{d(\pi_s)}{dw}=(a-bp)-b(w-c)\frac{d(p(w))}{dw}$. In fact, by MATHEMATICA, we have

$$\frac{d(\pi_s)}{dw}\geqslant 0\Leftrightarrow w<\frac{a+bc}{2b}$$
$$\cap\left[\left\{w\leqslant\frac{a+bc(2\gamma+1)}{2b(\gamma+1)}\right\}\cup\left[\begin{array}{c}\left\{w>\frac{a+bc(2\gamma+1)}{2b(1+\gamma)}\right\}\\ \cap\left\{c<w\leqslant w_{h2}\cup\frac{a+bc(2\gamma+1)}{2b(\gamma+1)}<w\leqslant w_{h3}\right\}\end{array}\right]\right]$$

where w_{h2} and w_{h3} are two real roots of equation $f_h(w)=0$ and

$$\begin{aligned}f_h(w)=&(a+bc-2bw)\left[a+bc+4bc\gamma-2bw(2\gamma+1)\right]\\&-b\gamma\rho_r(w-c)^2(a-bc)\left[a+bc+2bc\gamma-2bw(\gamma+1)\right]\end{aligned}$$

Besides, we have $c < w_{h2} < \frac{a+bc(2\gamma+1)}{2b(\gamma+1)} < w_{h3} < \frac{a}{b}$. In fact, equation $f_h(w) = 0$ has three real roots, w_{h1}, w_{h2}, and w_{h3}, but $w_{h1} < c$. Furthermore, $f_h\left(\frac{a+bc}{2b}\right) > 0$ and $\frac{a+bc}{2b} > \frac{a+bc(2\gamma+1)}{2b(\gamma+1)}$, so $\frac{a+bc}{2b} > w_{h3}$. Therefore, $\frac{d(\pi_s)}{dw} \geqslant 0 \Leftrightarrow c < w \leqslant w_{h3}$. That is, the curve of function $\pi_s(w)$ increases when $c < w \leqslant w_{h3}$ and decreases when $w_{h3} < w < \frac{a}{b}$.

Consequently, if $w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)}$ or $w_{h3} \geqslant w_{\rho_r}$, the optimal wholesale price $w^* = w_{h3}$ when $c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$ or $w_{\rho_r} \leqslant w < \frac{a}{b}$. If $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r}$, when $c < w < \frac{a+2b\gamma c}{b(2\gamma+1)}$ or $w_{\rho_r} \leqslant w < \frac{a}{b}$, we have to see which one is greater, $\pi_s\left(\frac{a+2b\gamma c}{b(2\gamma+1)}\right)$ or $\pi_s(w_{\rho_r})$ to derive the optimal wholesale price: if $\pi_s\left(\frac{a+2b\gamma c}{b(2\gamma+1)}\right) = \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$ is greater, then $w^* = \frac{a+2b\gamma c}{b(2\gamma+1)}$, otherwise, $w^* = w_{\rho_r}$. What we have to do next is to find the conditions for $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r}$ by comparing $\frac{a+2b\gamma c}{b(2\gamma+1)}$ and w_{h3}, w_{ρ_r}, and w_{h3}.

(1) Comparison between $\frac{a+2b\gamma c}{b(2\gamma+1)}$ and w_{h3}. With $\frac{(a+2b\gamma c)}{b(2\gamma+1)} > \frac{(a+bc(2\gamma+1))}{2b(\gamma+1)}$ and $c < w_{h2} < \frac{(a+bc(2\gamma+1))}{2b(\gamma+1)} < w_{h3} < \frac{a}{b}$, we have $f_h\left(\frac{a+2b\gamma c}{b(2\gamma+1)}\right) \geqslant 0 \Leftrightarrow b(1-2\gamma)(2\gamma+1)^2 + \rho_r\gamma(a-bc)^2 \geqslant 0$. Thus, $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} \Leftrightarrow b(1-2\gamma)(2\gamma+1)^2 + \rho_r\gamma(a-bc)^2 \leqslant 0$. Note that $b(1-2\gamma)(2\gamma+1)^2 + \rho_r\gamma(a-bc)^2 \leqslant 0$ holds when $\rho_r \to 0$ and $\gamma \geqslant \frac{1}{2}$ while it doesn't hold when $\gamma < \frac{1}{2}$.

(2) Comparison between w_{ρ_r} and w_{h3}. Let $\Delta(\mu) = w_{\rho_r}(\mu) - w_{h3}, \mu > \frac{1}{\gamma}$. Besides, we have

$$\frac{f_{\rho_r}(w)}{\mu^2} = \rho_r(w-c)^2\left[(a-bw) - \frac{1}{\mu}b(w-c)\right]b(\gamma - \frac{1}{\mu}) - \left[\frac{1}{\mu}2b(w-c) - (a-bw)\right]$$

It is obvious that w_{ρ_r} is also the unique real root of $\frac{f_{\rho_r}(w)}{\mu^2} = 0$. When $\mu \to \frac{1}{\gamma}$, $f_{\rho_r}(w) = -\frac{1}{\gamma}\left[2b(w-c) - \frac{1}{\gamma}(a-bw)\right]$, and thus $w_{\rho_r}(\mu) \to \frac{a+2b\gamma c}{b(2\gamma+1)}$; $\frac{f_{\rho_r}(w)}{\mu^2} = (a-bw)\left[b\gamma\rho_r(w-c)^2 + 1\right]$ if $\mu \to +\infty$, thus $w_{\rho_r}(\mu) \to \frac{a}{b}$. Hence, $\lim_{\mu \to \frac{1}{\gamma}} \Delta(\mu) = \frac{a+2b\gamma c}{b(2\gamma+1)} - w_{h3} \leqslant 0$ and $\lim_{\mu \to +\infty} \Delta(\mu) = \frac{a}{b} - w_{h3} > 0$. According to the property of continuity of function, we know that w_{h3} may be greater or smaller than w_{ρ_r}. However, we derive $w_{h3} < w_{\rho_r} \Leftrightarrow f_{\rho_r}(w_{h3}) > 0$. That is, we have

$$\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r} \Leftrightarrow \begin{cases} b(1-2\gamma)(2\gamma+1)^2 + \rho_r\gamma(a-bc)^2 \leqslant 0 \\ f_{\rho_r}(w_{h3}) > 0 \end{cases}$$

Therefore, we conclude this case and derive

$$
(w^*,p^*)=\begin{cases}
(w_{\rho_r},p^-)\ if \begin{cases} b\left(1-2\gamma\right)\left(2\gamma+1\right)^2+\rho_r\gamma(a-bc)^2\leqslant 0,\\ f_{\rho_r}\left(w_{h3}\right)>0\ \ and\ \ \pi_s(w_{\rho_r})\geqslant\frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}\end{cases}\\
(w_{h3},p^-)\ \ if\ \ b\left(1-2\gamma\right)\left(2\gamma+1\right)^2+\rho_r\gamma(a-bc)^2>0\ \ or\ \ f_{\rho_r}\left(w_{h3}\right)\leqslant 0\\
\left(\frac{a+2b\gamma c}{b(2\gamma+1)},p^-\right)if\begin{cases} b\left(1-2\gamma\right)\left(2\gamma+1\right)^2+\rho_r\gamma(a-bc)^2\leqslant 0,\\ f_{\rho_r}\left(w_{h3}\right)>0\ \ and\ \ \pi_s(w_{\rho_r})<\frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}\end{cases}
\end{cases}
$$

Case 2: If the retailer chooses a wholesale price from interval $\frac{a+2b\gamma c}{b(2\gamma+1)}\leqslant w<w_y$, the supplier's optimization problem is given by

$$
\max_{w}\quad (w-c)(a-bp) \tag{B.4}
$$

$$
s.t.\begin{cases} p=p^-_{\xi_r}\\ \frac{a+2b\gamma c}{b(2\gamma+1)}\leqslant w<w_y\end{cases} \tag{B.5}
$$

Because this case is similar to the previous case, we omit its deduction and simply provide its result as follows:

$$
(w^*,p^*)=\begin{cases}
\left(\frac{a+2b\gamma c}{b(2\gamma+1)},p^-_{\xi_r}\right)if\ \ b\left(1-2\gamma\right)\left(2\gamma+1\right)^2+\rho_r\xi_r\gamma(a-bc)^2>0\\
\left(w_{\xi h3},p^-_{\xi_r}\right)if\ \ b\left(1-2\gamma\right)\left(2\gamma+1\right)^2+\rho_r\xi_r\gamma(a-bc)^2\leqslant 0\ \ and\ \ Y(w_{\xi h3})<0\\
\left(w_y,p^-_{\xi_r}\right)if\ \ Y(w_{\xi h3})\geqslant 0
\end{cases}
$$

where $w_{\xi h3}$ is the greatest real root of equation $f_{\xi h}\left(w\right)=0$ and

$$
\begin{aligned}
f_{\xi h}\left(w\right)=&\left(a+bc-2bw\right)\left[a+bc+4bc\gamma-2bw\left(2\gamma+1\right)\right]\\
&-b\gamma\rho_r\xi_r(w-c)^2\left(a-bc\right)\left[a+bc+2bc\gamma-2bw\left(\gamma+1\right)\right]
\end{aligned}
$$

Case 3: If the retailer chooses a wholesale price from interval $w_y\leqslant w<w_{\rho_r}$, the supplier's optimization problem is given by

$$
\max_{w}\quad (w-c)(a-bp) \tag{B.6}
$$

$$
s.t.\begin{cases} p=\frac{(\mu+1)w-c}{\mu}\\ w_y\leqslant w<w_{\rho_r}\end{cases} \tag{B.7}
$$

When $w_y \leqslant w < w_{\rho_r}$, $p^* = \frac{(\mu+1)w-c}{\mu}$. Thus, we have $\pi_s = (w-c)\left(a - b\frac{(\mu+1)w-c}{\mu}\right)$,

$$\frac{d(\pi_s)}{dw} = \left(a - b\frac{(\mu+1)w-c}{\mu}\right) - b(w-c)\frac{(\mu+1)}{\mu}$$

$$\frac{d^2(\pi_s)}{dw^2} = -b\left[2\frac{dp}{dw} + (w-c)\frac{d^2p}{dw^2}\right] = -2b\frac{(\mu+1)}{\mu} < 0$$

By first-order condition $\frac{d(\pi_s)}{dw} = 0$, we obtain $w = \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}$. Furthermore, $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_{\rho_r}$ always holds and

$$Y\left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \geqslant 0 \Leftrightarrow \rho_r\xi_r(a-bc)^2(\gamma\mu-\mu-1) \geqslant 4b(1+\mu)^2$$

Therefore, we have the following two possibilities:

(a) When $\rho_r\xi_r(a-bc)^2(\gamma\mu-\mu-1) \geqslant 4b(1+\mu)^2$, we have $w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_{\rho_r}$, and thus $w^* = \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}, p^* = \frac{(\mu+1)w^*-c}{\mu} = \frac{a+bc}{2b}$.

(b) When $\rho_r\xi_r(a-bc)^2(\gamma\mu-\mu-1) < 4b(1+\mu)^2$, $w^* = w_y$.

We can conclude the results as follows:

$$(w^*, p^*) = \begin{cases} \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right) if\ \ \rho_r\xi_r(a-bc)^2(\gamma\mu-\mu-1) \geqslant 4b(1+\mu)^2 \\ \left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right) if\ \ \rho_r\xi_r(a-bc)^2(\gamma\mu-\mu-1) < 4b(1+\mu)^2 \end{cases}$$

The optimal wholesale price and the supplier's profit are given below

$$w = \begin{cases} \frac{(a+bc)\mu+2bc}{2b(\mu+1)}, T_3 \geqslant 0 \\ w_y, T_3 < 0 \end{cases} \tag{B.8}$$

$$\pi_s = \begin{cases} \frac{(a-bc)^2\mu}{4b(1+\mu)}, T_3 \geqslant 0 \\ (w_y-c)\left[a - b\frac{(\mu+1)w_y-c}{\mu}\right], T_3 < 0 \end{cases} \tag{B.9}$$

where $T_3 = (a-bc)^2(\gamma\mu-\mu-1)\rho_r\xi_r - 4b(1+\mu)^2$.

For the convenience of discussion, we rewrite the results of above three cases as follows:

Case 1:

$$\begin{cases} 1.1: (w^*, p^*) = \left(w_{\rho_r}, p^-\right), \pi_s^{1.1} = (w_{\rho_r} - c)\left[a - bp^-\left(w_{\rho_r}\right)\right] \\ if \ \ \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r} \ and \ \ \pi_s^{1.1} \geqslant \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \\ 1.2: (w^*, p^*) = (w_{h3}, p^-), \pi_s^{1.2} = (w_{h3} - c)\left[a - bp^-(w_{h3})\right] \\ if \ \ c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)} \ \ or \ w_{\rho_r} \leqslant w_{h3} < \frac{a}{b} \\ 1.3: (w^*, p^*) = \left(\frac{a+2b\gamma c}{b(2\gamma+1)}, p^-\right), \pi_s^{1.3} = \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \\ if \ \ \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r} \ and \ \ \pi_s^{1.1} < \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \end{cases}$$

Case 2:

$$\begin{cases} 2.1: (w^*, p^*) = \left(\frac{a+2b\gamma c}{b(2\gamma+1)}, p_{\xi_r}^-\right), \pi_s^{2.1} = \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \\ if \ \ c < w_{\xi h3} < \frac{a+2b\gamma c}{b(2\gamma+1)} \\ 2.2: (w^*, p^*) = \left(w_{\xi h3}, p_{\xi_r}^-\right), \pi_s^{2.2} = (w_{\xi h3} - c)\left[a - bp_{\xi_r}^-\left(w_{\xi h3}\right)\right] \\ if \ \ \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi h3} < w_y \\ 2.3: (w^*, p^*) = \left(w_y, p_{\xi_r}^-\right), \pi_s^{2.3} = (w_y - c)\left[a - bp_{\xi_r}^-(w_y)\right] \\ if \ \ w_y \leqslant w_{\xi h3} < \frac{a}{b} \end{cases}$$

Case 3:

$$\begin{cases} 3.1: (w^*, p^*) = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right), \pi_s^{3.1} = \frac{(a-bc)^2\mu}{4b(1+\mu)} \\ if \ \ c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)} \\ 3.2: (w^*, p^*) = \left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right), \pi_s^{3.2} = (w_y - c)\left[a - b\frac{(\mu+1)w_y-c}{\mu}\right] \\ if \ \ \frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b} \end{cases}$$

We know that $p^- \geqslant \frac{(\mu+1)w-c}{\mu} \Leftrightarrow c < w \leqslant w_{\rho_r}$, so when $c < w \leqslant w_{\rho_r}$ we have

$$\pi_s = (w-c)\left[a - bp^-(w)\right] \leqslant (w-c)\left[a - b\frac{(\mu+1)w-c}{\mu}\right]$$

Besides, $w = \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}$ is the optimal value of $\varphi(w) = (w-c)\left[a - b\frac{(\mu+1)w-c}{\mu}\right]$, thus,

$$(w-c)\left[a - bp^-(w)\right] \leqslant \varphi\left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}\right) = \frac{(a-bc)^2\mu}{4b(1+\mu)}$$

Likewise, $(w-c)\left[a - bp_{\xi_r}^-(w)\right] \leqslant \frac{(a-bc)^2\mu}{4b(1+\mu)}$ if $c < w \leqslant w_{\rho\xi_r}$.

Scenario 1: $c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}$;

Obviously, both $\pi_s^{1.1}$ and $\pi_s^{1.3}$ are less than $\frac{(a-bc)^2\mu}{4b(1+\mu)}$. For 2.1, 2.2 and 2.3, we have $\frac{a+2b\gamma c}{b(2\gamma+1)} < w_{\rho\xi_r}$, $w_{\xi h3} < w_y < w_{\rho_{\xi_r}}$ and $w_y < w_{\rho\xi_r}$ respectively. That is, $\pi_s^{2.1}$, $\pi_s^{2.2}$ and $\pi_s^{2.3}$ are all less than $\frac{(a-bc)^2\mu}{4b(1+\mu)}$. Furthermore, $\pi_s^{1.2}$ is also less than $\frac{(a-bc)^2\mu}{4b(1+\mu)}$ if $c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)}$ holds. However, $\pi_s^{1.2}$ may be smaller (for example, let $a = 1, b = 0.1, c = 0.2, \gamma = 10, \mu = 0.15, \rho_r = 3, \xi_r = 0.8$) or greater (for example, let $a = 1, b = 0.1, c = 0.2, \gamma = 10, \mu = 0.15, \rho_r = 1.8, \xi_r = 0.95$) than $\frac{(a-bc)^2\mu}{4b(1+\mu)}$ when $w_{\rho r} < w_{h3} < \frac{a}{b}$.

In summary, the global equilibrium will be

$$(w^*, p^*) = \begin{cases} \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right) \\ if \ \left(c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \wedge \left[\left(c < w_{h3} \leqslant w_{\rho_r}\right) \vee \left(\pi_s^{1.2} \leqslant \frac{(a-bc)^2\mu}{4b(1+\mu)}\right)\right] \\ \left(w_{h3}, p^-\left(w_{h3}\right)\right) \\ if \ \left(c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \wedge \left(w_{\rho_r} < w_{h3} < \frac{a}{b}\right) \wedge \left(\pi_s^{1.2} > \frac{(a-bc)^2\mu}{4b(1+\mu)}\right) \end{cases}$$

Scenario 2: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}$;

Firstly, it is not difficult to demonstrate the following six inequalities:

(1) $\pi_s^{1.1} = (w_{\rho_r} - c)\left[a - bp^-\left(w_{\rho_r}\right)\right] < \pi_s^{3.2}$; (2) $\pi_s^{2.3} = (w_y - c)\left[a - bp^-_{\xi_r}\left(w_y\right)\right] < \pi_s^{3.2}$; (3) $\pi_s^{1.2} = (w_{h3} - c)\left[a - bp^-\left(w_{h3}\right)\right] > \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$; (4) $\pi_s^{2.2} = (w_{\xi h3} - c)\left[a - bp^-_{\xi_r}\left(w_{\xi h3}\right)\right] > \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$; (5)$w_{\xi h3} > w_{h3}$; (6) $w_y < w_{\rho\xi_r} < w_{\rho_r}$.

Based on these six important inequalities, we have to discuss the following seven combinations:

(I): 1.1 *versus* 2.2 *versus* 3.2. We have already demonstrated that $\pi_s^{1.1} < \pi_s^{3.2}$. However, $\pi_s^{2.2}$ may greater (for example, let $a = 1, b = 4, c = 0.2, \gamma = 3, \mu = 2.1, \rho = 0.1, \xi = 0.5$) or smaller (for example, let $a = 1, b = 4, c = 0.2, \gamma = 3, \mu = 2, \rho = 1, \xi = 0.5$) than $\pi_s^{3.2}$. If $\pi_s^{2.2} > \pi_s^{3.2}$, the global equilibrium will be $\left(w_{\xi h3}, p^-_{\xi_r}\left(w_{\xi h3}\right)\right)$; If $\pi_s^{2.2} \leqslant \pi_s^{3.2}$, the global equilibrium is $\left(w_y, \frac{(\mu+1)w_y - c}{\mu}\right)$. The constraint (it must ensure that 1.1, 2.2 and 3.2 can coexist) is the intersection of the following sets: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y$, $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\xi h3} < w_y < w_{\rho r}$ and $\pi_s^{1.1} \geqslant \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$.

(II): 1.1 *versus* 2.3 *versus* 3.2. We know that $\pi_s^{1.1} < \pi_s^{3.2}$ and $\pi_s^{2.3} < \pi_s^{3.2}$, so the global equilibrium is $(w_y, ((\mu+1)w_y - c)/\mu)$.The constraint is the intersection of the following sets: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y$, $\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r}$, $\pi_s^{1.1} \geqslant \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$ and $w_y \leqslant w_{\xi h3} < \frac{a}{b}$.

(III): 1.2 *versus* 2.1 *versus* 3.2. $\pi_s^{1.2} > \pi_s^{2.1}$ is guaranteed, but $\pi_s^{1.2}$ may be greater (for example, let $a=1,b=4,c=0.2,\gamma=0.35,\mu=3,\rho=2,\xi=0.5$) or smaller (for example, let $a=5,b=1,c=0.2,\gamma=1,\mu=2,\rho=5,\xi=0.8$) than $\pi_s^{3.2}$. When $\pi_s^{1.2}>\pi_s^{3.2}$, the global equilibrium is $(w_{h3},p^-(w_{h3}))$; when $\pi_s^{1.2}\leqslant\pi_s^{3.2}$, the global equilibrium is $\left(w_y,\frac{(\mu+1)w_y-c}{\mu}\right)$. The constraint is the intersection of the following sets: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}<w_y$ and $c<w_{h3}<w_{\xi h3}<\frac{a+2b\gamma c}{b(2\gamma+1)}$.

(IV): 1.2 *versus* 2.2 *versus* 3.2. In fact, $\pi_s^{1.2}$ or $\pi_s^{2.2}$ or $\pi_s^{3.2}$ are all candidates to be the greatest one. When $\pi_s^{1.2}>\pi_s^{3.2}$ and $\pi_s^{1.2}\geqslant\pi_s^{2.2}$ (for example, let $a=5,b=1,c=0.2,\gamma=0.7,\mu=2.2,\rho=1,\xi=0.01$), the global equilibrium is $(w_{h3},p^-(w_{h3}))$; if $\pi_s^{2.2}>\pi_s^{3.2}$ and $\pi_s^{2.2}>\pi_s^{1.2}$ (for example, let $a=2,b=7,c=0.2,\gamma=0.503,\mu=2.1,\rho=1,\xi=0.3$), the global equilibrium is $\left(w_{\xi h3},p^-_{\xi_r}(w_{\xi h3})\right)$; when $\pi_s^{3.2}\geqslant\pi_s^{1.2}$ and $\pi_s^{3.2}\geqslant\pi_s^{2.2}$ (for example, let $a=5,b=1,c=0.2,\gamma=1,\mu=2,\rho=1,\xi=0.01$), the global equilibrium will be $\left(w_y,\frac{(\mu+1)w_y-c}{\mu}\right)$. The constraint is the intersection of the following sets: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}<w_y$ and $c<w_{h3}<\frac{a+2b\gamma c}{b(2\gamma+1)}\leqslant w_{\xi h3}<w_y$.

(V): 1.2 *versus* 2.3 *versus* 3.2. $\pi_s^{2.3}<\pi_s^{3.2}$ is guaranteed. However, $\pi_s^{1.2}$ may be greater (for example, let $a=5,b=1,c=0.2,\gamma=1,\mu=1.1,\rho=5,\xi=0.02$) or smaller (for example, let $a=5,b=1,c=0.2,\gamma=1,\mu=1.3,\rho=5,\xi=0.02$) than $\pi_s^{3.2}$. When $\pi_s^{1.2}>\pi_s^{3.2}$, the global equilibrium is $(w_{h3},p^-(w_{h3}))$; if $\pi_s^{1.2}\leqslant\pi_s^{3.2}$, the global equilibrium will be $\left(w_y,\frac{(\mu+1)w_y-c}{\mu}\right)$. The constraint is the intersection of the following sets: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}<w_y$, $w_y\leqslant w_{\xi h3}<\frac{a}{b}$ and $\left(c<w_{h3}<\frac{a+2b\gamma c}{b(2\gamma+1)}\ or\ w_{\rho r}\leqslant w_{h3}<\frac{a}{b}\right)$.

(VI): 1.3 *versus* 2.2 *versus* 3.2. We can ensure that $\pi_s^{1.3}<\pi_s^{2.2}$. However, $\pi_s^{2.2}$ may be greater (for example, let $a=1,b=4,c=0.2,\gamma=0.501,\mu=2.1,\rho=0.00001,\xi=0.005$) or smaller (for example, let $a=1,b=0.2,c=0.2,\gamma=3,\mu=1.5,\rho=1,\xi=0.5$) than $\pi_s^{3.2}$. If $\pi_s^{2.2}>\pi_s^{3.2}$, the global equilibrium is $\left(w_{\xi h3},p^-_{\xi_r}(w_{\xi h3})\right)$; if $\pi_s^{2.2}\leqslant\pi_s^{3.2}$, the global equilibrium will be $\left(w_y,\frac{(\mu+1)w_y-c}{\mu}\right)$. The constraint is the intersection of the following sets: $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}<w_y$, $\frac{a+2b\gamma c}{b(2\gamma+1)}\leqslant w_{h3}<w_{\xi h3}<w_y$ and $\pi_s^{1.1}<\frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$.

(VII): 1.3 *versus* 2.3 *versus* 3.2. We have already demonstrated that $\pi_s^{2.3}<\pi_s^{3.2}$. Besides, it is not difficult to demonstrate that $\pi_s^{1.3}<\pi_s^{3.2}$. Thus, the global equilibrium will be $\left(w_y,\frac{(\mu+1)w_y-c}{\mu}\right)$. The constraint is the intersection of the following sets: $\pi_s^{1.1}<\frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}$, $\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}<w_y\leqslant w_{\xi h3}<\frac{a}{b}$ and $\frac{a+2b\gamma c}{b(2\gamma+1)}\leqslant w_{h3}<w_{\rho_r}$.

To sum up, after combining the results of scenario 1 and scenario 2, the global equilibrium is given by

$$\left(w_{gl}^{*}, p_{gl}^{*}\right) = \begin{cases} \left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right) \ if \ CON1 \\ \left(w_{h3}, p^{-}\left(w_{h3}\right)\right) \ if \ CON2 \\ \left(w_{\xi h3}, p_{\xi_r}^{-}\left(w_{\xi h3}\right)\right) \ if \ CON3 \\ \left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right) \ if \ CON4 \end{cases} \tag{B.10}$$

where $CON1 = \left(c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \wedge \left[\left(c < w_{h3} \leqslant w_{\rho_r}\right) \vee \left(\pi_s^{1.2} \leqslant \frac{(a-bc)^2\mu}{4b(1+\mu)}\right)\right]$, $CON2 = U_{21} \vee U_{22} \vee U_{23} \vee U_{24}$, $CON3 = U_{31} \vee U_{32} \vee U_{33}$, and $CON4 = U_{41} \vee U_{42} \vee U_{43} \vee U_{44} \vee U_{45} \vee U_{46}$.

$$U_{21} = \left(c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \wedge \left(w_{\rho_r} < w_{h3} < \frac{a}{b}\right) \wedge \left(\pi_s^{1.2} > \frac{(a-bc)^2\mu}{4b(1+\mu)}\right);$$

$$U_{22} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(c < w_{h3} < w_{\xi h3} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \wedge \left(\pi_s^{1.2} > \pi_s^{3.2}\right);$$

$$\begin{aligned} U_{23} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi h3} < w_y\right) \\ & \wedge \left(\pi_s^{1.2} > \pi_s^{3.2}\right) \wedge \left(\pi_s^{1.2} \geqslant \pi_s^{2.2}\right); \end{aligned}$$

$$\begin{aligned} U_{24} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left[\left(c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{h3} < \frac{a}{b}\right)\right] \\ & \wedge \left(w_y \leqslant w_{\xi h3} < \frac{a}{b}\right) \wedge \left(\pi_s^{1.2} > \pi_s^{3.2}\right); \end{aligned}$$

$$\begin{aligned} U_{31} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\xi h3} < w_y\right) \\ & \wedge \left(\pi_s^{1.1} \geqslant \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}\right) \wedge \left(\pi_s^{2.2} > \pi_s^{3.2}\right); \end{aligned}$$

$$\begin{aligned} U_{32} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi h3} < w_y\right) \\ & \wedge \left(\pi_s^{2.2} > \pi_s^{3.2}\right) \wedge \left(\pi_s^{2.2} > \pi_s^{1.2}\right); \end{aligned}$$

$$\begin{aligned} U_{33} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\xi h3} < w_y\right) \\ & \wedge \left(\pi_s^{1.1} < \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}\right) \wedge \left(\pi_s^{2.2} > \pi_s^{3.2}\right); \end{aligned}$$

$$U_{41} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\xi h3} < w_y\right) \wedge \left(\pi_s^{2.2} \leqslant \pi_s^{3.2}\right);$$

$$\begin{aligned} U_{42} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r}\right) \\ & \wedge \left(\pi_s^{1.1} \geqslant \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}\right) \wedge \left(w_y \leqslant w_{\xi h3} < \frac{a}{b}\right); \end{aligned}$$

$$U_{43} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(c < w_{h3} < w_{\xi h3} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \wedge \left(\pi_s^{1.2} \leqslant \pi_s^{3.2}\right);$$

$$\begin{aligned} U_{44} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi h3} < w_y\right) \\ & \wedge \left(\pi_s^{3.2} \geqslant \pi_s^{1.2}\right) \wedge \left(\pi_s^{3.2} \geqslant \pi_s^{2.2}\right); \end{aligned}$$

$$\begin{aligned} U_{45} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left[\left(c < w_{h3} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{h3} < \frac{a}{b}\right)\right] \\ & \wedge \left(w_y \leqslant w_{\xi h3} < \frac{a}{b}\right) \wedge \left(\pi_s^{1.2} \leqslant \pi_s^{3.2}\right); \end{aligned}$$

$$\begin{aligned} U_{46} = & \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{h3} < w_{\rho_r}\right) \wedge \left(\pi_s^{1.1} < \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2}\right) \\ & \wedge \left(w_y \leqslant w_{\xi h3} < \frac{a}{b}\right) \wedge \left(\pi_s^{1.3} \leqslant \pi_s^{3.2}\right). \end{aligned}$$

B.2.2 The traditional supplier's decisions of the harmonious channel

The traditional supplier's optimal decisions are much easier when $\gamma\mu \leqslant 1$. If $\gamma\mu \leqslant 1$, the best response function is $p(w) = p^{-}(w)$. Therefore, the equilibrium will be $(w_{h3}, p^{-}(w_{h3}))$. □

B.3 Proof of proposition 4.2.

Proof. (A) If $0 < \rho_r \leqslant \frac{4b}{(a-bc)^2}$, then $\frac{\partial(p^{-}(w))}{\partial w} > 0$ when $c < w < \frac{a}{b}$;

(B) if $\rho_r > \frac{4b}{(a-bc)^2}$, then $\frac{\partial(p^{-}(w))}{\partial w} > 0$ when $w_{q2} < w < \frac{a}{b}$ and $\frac{\partial(p^{-}(w))}{\partial w} < 0$ when $c < w < w_{q2}$. Equation $Q(w) = 0$ has four real roots and the second smallest one is w_{q2}. Furthermore, we have $Q(c) = 4b - \rho_r(a-bc)^2 < 0$, $Q(\frac{a}{b}) = 4b - \rho_r(a-bc)^2 - \frac{(a-bc)^4\gamma(1+\gamma)(\rho_r)^2}{b} < 0$, $\left.\frac{\partial(Q(w))}{\partial w}\right|_{w=c} = 4b(a-bc)(1+\gamma)\rho_r > 0$, $\left.\frac{\partial(Q(w))}{\partial w}\right|_{w=\frac{a}{b}} = -(a-bc)2(1+\gamma)\rho_r\left(2b + (a-bc)^2\gamma\rho_r\right) < 0$, and $Q\left(\frac{a+2b\gamma c}{b(2\gamma+1)}\right) \geqslant 0 \Leftrightarrow \gamma \geqslant \frac{(a-bc)}{4}\sqrt{\frac{\rho_r}{b}} - \frac{1}{2} > 0$.

Besides, the coefficient of the term with the highest power is positive, therefore,

(a) if $\gamma \geqslant \frac{(a-bc)\sqrt{\rho_r}}{4\sqrt{b}} - \frac{1}{2}$, then $(a+2b\gamma c)/(b(2\gamma+1)) \geqslant w_{q2}$;

(b) if $0 < \gamma < \left((a-bc)\sqrt{\rho_r}\right)/(4\sqrt{b}) - (1/2)$, since we have $\left.\frac{\partial(Q(w))}{\partial w}\right|_{w=(a+2b\gamma c)/(b(2\gamma+1))} < 0$, thus, $(a+2b\gamma c)/(b(2\gamma+1)) \geqslant w_{q2}$. That is, $(a+2b\gamma c)/(b(2\gamma+1)) \geqslant w_{q2}$ if $\rho_r > (4b)/(a-bc)^2$. □

B.4 Proof of the global equilibrium of the channel in which both members have the preferences of reciprocity

B.4.1 The reciprocal supplier's decisions of the acrimonious channel

We handle case 1 as an example. Analyses of the other two cases are similar and therefore omitted. In order to solve the optimization problem (35) with the constraint of (36), we first derive the first-order condition of Eq. (35). Additionally, at equilibrium, the beliefs equal real actions, thus, we have $(a-bp) - b(w-c)\frac{dp}{dw} - \rho_s(a-bp)^2[w(\mu+1) - \mu p - c] = 0$. Then, let $J(w) = (a-bp) - b(w-c)\frac{dp}{dw} - \rho_s(a-bp)^2[w(\mu+1) - \mu p - c]$, where $p = p^{-}(w)$. When $w_{h3} < w_{\rho_r}$, we have

(a) $(a-bp) - b(w-c)\frac{dp}{dw} > 0$ and $\rho_s(a-bp)^2[w(\mu+1) - \mu p - c] < 0$ when $c < w < w_{h3}$

and thus $J(w) > 0$;

(b) $(a-bp)-b(w-c)\frac{dp}{dw} < 0$ and $\rho_s(a-bp)^2\left[w(\mu+1)-\mu p-c\right] > 0$ when $w_{\rho_r} < w < \frac{a}{b}$ and thus $J(w) < 0$.

Furthermore, $J(w_{h3}) = -\rho_s(a-bp)^2\left[w(\mu+1)-\mu p-c\right] > 0$ and $J(w_{\rho_r}) = (a-bp)-b(w-c)\frac{dp}{dw} < 0$. Therefore, there must be at least one real root of equation $J(w)=0$ that falls into the interval (w_{h3}, w_{ρ_r}).

Using the same reasoning, for $w_{h3} > w_{\rho_r}$, there is at least one real root of $J(w)=0$ that falls into the interval (w_{ρ_r}, w_{h3}). If $w_{h3} = w_{\rho_r}$, the unique real root of equation $J(w)=0$ which belongs to $(c, \frac{a}{b})$ will be w_{h3} or w_{ρ_r}.

All in all, equation $J(w)=0$ has at least one real root which falls into the space between w_{h3} or w_{ρ_r} and it (they) belongs (belong) to set W_J. W_J has limited elements and we can always find one element w_{rsp} as the reciprocal supplier's optimal choice. However, there may exist two or even more real roots for $J(w)=0$. If so, w_{rsp} will be the one which maximizes the profit function $\Pi_s = (w-c)(a-bp^-)$, because the supplier's profit equals her utility in equilibrium at this moment.

Likewise, let $J_\xi(w) = (a-bp)-b(w-c)\frac{dp}{dw} - \rho_s\xi_s(a-bp)^2\left[w(\mu+1)-\mu p-c\right]$, where $p = p^-_{\xi_r}(w)$. Equation $J_\xi(w)=0$ also has at least one real root which fall into space between w_{h3} or w_{ρ_r} and the optimal wholesale price the reciprocal supplier charges is $w_{\xi rsp}$.

Based on the results and the method of analysis in the discussion of the channel consisting of reciprocal retailer and traditional supplier, it is not difficult to derive the following equilibria and corresponding constraints for the three cases:

Case 1:

$$\begin{cases} A1:\ (w^*,p^*) = \left(w_{\rho_r}, p^-\right), \pi_s^{A1} = (w_{\rho_r}-c)\left[a-bp^-\left(w_{\rho_r}\right)\right] \\ if\ \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{rsp} < w_{\rho_r}\ and\ \pi_s\left(w_{\rho_r}\right) \geqslant \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \\ A2:(w^*,p^*) = \left(w_{rsp}, p^-\right), \pi_s^{A2} = (w_{rsp}-c)\left[a-bp^-\left(w_{rsp}\right)\right] \\ if\ c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\ or\ w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b} \\ A3:(w^*,p^*) = \left(\frac{a+2b\gamma c}{b(2\gamma+1)}, p^-\right), \pi_s^{A3} = \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \\ if\ \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{rsp} < w_{\rho_r}\ and\ \pi_s\left(w_{\rho_r}\right) < \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \end{cases}$$

Case 2:

$$\begin{cases} B1: (w^*, p^*) = \left(\frac{a+2b\gamma c}{b(2\gamma+1)}, p^-_{\xi_r}\right), \pi_s^{B1} = \frac{(a-bc)^2\gamma}{b(1+2\gamma)^2} \\ if \;\; c < w_{\xi rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)} \\ B2: (w^*, p^*) = \left(w_{\xi rsp}, p^-_{\xi_r}\right), \pi_s^{B2} = (w_{\xi rsp} - c)\left[a - bp^-_{\xi_r}\left(w_{\xi rsp}\right)\right] \\ if \;\; \frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y \\ B3: (w^*, p^*) = \left(w_y, p^-_{\xi_r}\right), \pi_s^{B3} = (w_y - c)\left[a - bp^-_{\xi_r}(w_y)\right] \\ if \;\; w_y \leqslant w_{\xi rsp} < \frac{a}{b} \end{cases}$$

Case 3:

$$\begin{cases} C1: (w^*, p^*) = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right), \pi_s^{C1} = \frac{(a-bc)^2\mu}{4b(1+\mu)} \\ if \;\; c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)} \\ C2: (w^*, p^*) = \left(w_y, \frac{(\mu+1)w_y - c}{\mu}\right), \pi_s^{C2} = (w_y - c)\left[a - b\frac{(\mu+1)w_y - c}{\mu}\right] \\ if \;\; \frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b} \end{cases}$$

For case 1, a unique optimal wholesale price can be found since it has the same second-derivative function with that of $\gamma\mu \leqslant 1$ (we have demonstrated that it is unimodal and thus we can find the unique optimal wholesale price anyway). Case 2 has utility function similar to case 1 except ρ_s is replaced by $\rho_s\xi_s$, where ξ_s is a positive parameter, so its uniqueness can also be guaranteed. Case 3 is much easier and we can immediately derive that its second-derivative function is negative, which shows that it is a concave function and has a unique wholesale price.

The reciprocal supplier will compare above three cases and then obtain the globally optimal wholesale price. For the sake of simplicity, we omit the comparison process since it has analysis similar to previous scenario in which the retailer has a preference for reciprocity while the supplier is a profit-maximizer, and we simply provide the ultimate results. The global equilibrium has the following four possibilities: To sum up, after combining the results of scenario 1 and scenario 2, the global equilibrium is given by

$$(w^*_{rgl}, p^*_{rgl}) = \begin{cases} \left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right) \;\; if \;\; RCON1 \\ \left(w_{rsp}, p^-\left(w_{rsp}\right)\right) \;\; if \;\; RCON2 \\ \left(w_{\xi rsp}, p^-_{\xi_r}\left(w_{\xi rsp}\right)\right) \;\; if \;\; RCON3 \\ \left(w_y, \frac{(\mu+1)w_y - c}{\mu}\right) \;\; if \;\; RCON4 \end{cases} \tag{B.11}$$

where $RCON1 = \left(c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \wedge \left[\left(c < w_{rsp} \leqslant w_{\rho_r}\right) \vee \left(\pi_s^{A2} \leqslant \frac{(a-bc)^2\mu}{4b(1+\mu)}\right)\right]$, $RCON2 = G_{21} \vee G_{22} \vee G_{23}$, $RCON3 = G_{31} \vee G_{32}$, $RCON4 = \bar{Q} \wedge \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right)$, and $Q = G_{41} \vee G_{42} \vee G_{43} \vee G_{44}$.

$$G_{21} = \left(c < w_y \leqslant \frac{a\mu+bc\mu+2bc}{2b(1+\mu)}\right) \wedge \left(w_{\rho_r} < w_{rsp} < \frac{a}{b}\right) \wedge \left(\pi_s^{A2} > \frac{(a-bc)^2\mu}{4b(1+\mu)}\right);$$

$$G_{22} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left[\left(c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b}\right)\right]$$
$$\wedge \left[\left(c < w_{\xi rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_y \leqslant w_{\xi rsp} < \frac{a}{b}\right)\right] \wedge \left(\pi_s^{A2} > \pi_s^{C2}\right);$$

$$G_{23} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left[\left(c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b}\right)\right]$$
$$\wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y\right) \wedge \left(\pi_s^{A2} > \pi_s^{C2}\right) \wedge \left(\pi_s^{A2} \geqslant \pi_s^{B2}\right).$$

$$G_{31} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{rsp} < w_{\rho_r}\right)$$
$$\wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y\right) \wedge \left(\pi_s^{B2} > \pi_s^{C2}\right);$$

$$G_{32} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left[\left(c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b}\right)\right]$$
$$\wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y\right) \wedge \left(\pi_s^{B2} > \pi_s^{C2}\right) \wedge \left(\pi_s^{A2} < \pi_s^{B2}\right).$$

$$G_{41} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left[\left(c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b}\right)\right]$$
$$\wedge \left[\left(c < w_{\xi rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_y \leqslant w_{\xi rsp} < \frac{a}{b}\right)\right] \wedge \left(\pi_s^{A2} > \pi_s^{C2}\right);$$

$$G_{42} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left[\left(c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b}\right)\right]$$
$$\wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y\right) \wedge \left(\pi_s^{A2} > \pi_s^{C2}\right) \wedge \left(\pi_s^{A2} \geqslant \pi_s^{B2}\right);$$

$$G_{43} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{rsp} < w_{\rho_r}\right)$$
$$\wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y\right) \wedge \left(\pi_s^{B2} > \pi_s^{C2}\right);$$

$$G_{44} = \left(\frac{a\mu+bc\mu+2bc}{2b(1+\mu)} < w_y < \frac{a}{b}\right) \wedge \left[\left(c < w_{rsp} < \frac{a+2b\gamma c}{b(2\gamma+1)}\right) \vee \left(w_{\rho_r} \leqslant w_{rsp} < \frac{a}{b}\right)\right]$$
$$\wedge \left(\frac{a+2b\gamma c}{b(2\gamma+1)} \leqslant w_{\xi rsp} < w_y\right) \wedge \left(\pi_s^{B2} > \pi_s^{C2}\right) \wedge \left(\pi_s^{A2} < \pi_s^{B2}\right).$$

Additionally, the following four examples of assignment are used to show that all four of the above optimal equilibria actually exist:

(1) when $a = 10, b = 2, c = 1, \gamma = 10, \mu = 0.15, \rho_r = 1, \rho_s = 1, \xi_r = 0.5, \xi_s = 0.5$, the global equilibrium is $\left(\frac{(a+bc)\mu+2bc}{2b(1+\mu)}, \frac{a+bc}{2b}\right)$;

(2) when $a = 10, b = 2, c = 1, \gamma = 10, \mu = 0.11, \rho_r = 1, \rho_s = 1, \xi_r = 0.5, \xi_s = 0.5$, the global equilibrium is (w_{rsp}, p^-);

(3) when $a = 2, b = 7, c = 0.2, \gamma = 0.51, \mu = 2.1, \rho_r = 1, \rho_s = 0.1, \xi_r = 0.3, \xi_s = 0.1$, the global equilibrium is $\left(w_{\xi rsp}, p_{\xi_r}^-\right)$;

(4) when $a = 10, b = 2, c = 1, \gamma = 1.5, \mu = 1, \rho_r = 1, \rho_s = 1, \xi_r = 0.5, \xi_s = 0.5$, the global

equilibrium is $\left(w_y, \frac{(\mu+1)w_y-c}{\mu}\right)$.

B.4.2 The reciprocal supplier's decisions of the harmonious channel

Likewise, the equilibrium becomes easier when $\gamma\mu \leqslant 1$. If $\gamma\mu \leqslant 1$, the best response function is $p(w) = p^{-}(w)$ and the equilibrium will be $(w_{rsp}, p^{-}(w_{rsp}))$. $\square$

Bibliography

Abou-Kandil, H. and Bertrand, P. (1985). Analytical solution for an open-loop stackelberg game. *Automatic Control, IEEE Transactions on*, 30(12):1222–1224.

Anupindi, R. and Bassok, Y. (1999). Centralization of stocks: Retailers vs. manufacturer. *Management Science*, 45(2):178–191.

Arcelus, F. J., Kumar, S., and Srinivasan, G. (2012). Risk tolerance and a retailer's pricing and ordering policies within a newsvendor framework. *Omega*, 40(2):188–198.

Ardzrooni, L., Veblen, T. B., Veblen, T. B., Economiste, S., and Veblen, T. B. (1934). *Essays in Our Changing Order*. Viking Press.

Bagwell, L. S. and Bernheim, B. D. (1996). Veblen effects in a theory of conspicuous consumption. *American Economic Review*, 86(3):349–373.

Ball, S., Eckel, C., Grossman, P. J., and Zame, W. (2001). Status in markets. *Quarterly Journal of Economics*, 116(1):161–188.

Ball, S. B. and Eckel, C. C. (1996). Buying status: Experimental evidence on status in negotiation. *Psychology and Marketing*, 13(4):379–403.

Barlow, J. (1989). Darwin, sex and status.

Basar, T. and Olsder, G. (1982). Dynamic noncooperative game theory.

Bendoly, E., Donohue, K., and Schultz, K. L. (2006). Behavior in operations management: Assessing recent findings and revisiting old assumptions. *Journal of Operations Management*, 24(6):737–752.

Berg, J., Dickhaut, J., and McCabe, K. (1995). Trust, reciprocity, and social history. *Games and economic behavior*, 10(1):122–142.

Berger, J., Cohen, B. P., and Zelditch Jr, M. (1972). Status characteristics and social interaction. *American Sociological Review*, pages 241–255.

Bernstein, F. and Federgruen, A. (2005). Decentralized supply chains with competing retailers under demand uncertainty. *Management Science*, 51(1):18–29.

Binmore, K. (1980). Nash bargaiing theory ii. *ICERD Discussion Paper 14*.

Binmore, K., Rubinstein, A., and Wolinsky, A. (1986). The nash bargaining solution in economic modelling. *RAND Journal of Economics*, pages 176–188.

Bisin, A. and Verdier, T. (1998). On the cultural transmission of preferences for social status. *Journal of Public Economics*, 70(1):75–97.

Bitran, G. R., Haas, E. A., and Matsuo, H. (1986). Production planning of style goods with high setup costs and forecast revisions. *Operations Research*, 34(2):226–236.

Blanco, M., Engelmann, D., and Normann, H. T. (2011). A within-subject analysis of other-regarding preferences. *Games and Economic Behavior*, 72(2):321–338.

Blinder, A. S. and Choi, D. H. (1990). A shred of evidence on theories of wage stickiness. *Quarterly Journal of Economics*, 105(4):1003–1015.

Blount, S. (1995). When social outcomes aren't fair: The effect of causal attributions on preferences. *Organizational Behavior and Human Decision Processes*, 63(2):131–144.

Bolton, G. (1991). A comparative model of bargaining: Theory and evidence. *American Economic Review*, 81(5):1096–1136.

Bolton, G. and Ockenfels, A. (2000). ERC: A theory of equity, reciprocity, and competition. *American Economic Review*, 90(1):166–193.

Booth, A., Shelley, G., Mazur, A., Tharp, G., and Kittok, R. (1989). Testosterone, and winning and losing in human competition. *Hormones and behavior*, 23(4):556–571.

Brandts, J. and Solà, C. (2001). Reference points and negative reciprocity in simple sequential games. *Games and Economic Behavior*, 36(2):138–157.

Bresnahan, T. F. and Reiss, P. C. (1985). Dealer and manufacturer margins. *Rand Journal of Economics*, 16(2):253–268.

Breton, M., Alj, A., and Haurie, A. (1988). Sequential stackelberg equilibria in two-person games. *Journal of Optimization Theory and Applications*, 59(1):71–97.

Bryan, J., Wadsworth, G., and Whitin, T. (1955). A multi-stage inventory model. *Naval Research Logistics Quarterly*, 2(1-2):25–37.

Buss, D. M. (2004). Evolutionary psychology. *Boston: Pearson Education.*

Cachon, G. P. (1999). Competitive supply chain inventory management. In *Quantitative models for supply chain management*, pages 111–146. Springer.

Cachon, G. P. (2003). Supply chain coordination with contracts. In Graves, S. C. and de Kok, A. G., editors, *Handbooks in Operations Research and Management Science (vol. 11)- Supply Chain Management: Design, Coordination and Operation*, pages 229–340. Elsevier, North-Holland.

Cachon, G. P. and Lariviere, M. A. (2005). Supply chain coordination with revenue-sharing contracts: strengths and limitations. *Management Science*, 51(1):30–44.

Cachon, G. P. and Netessine, S. (2004). Game theory in supply chain analysis. In *Handbook of Quantitative Supply Chain Analysis*, pages 13–65. Springer.

Caliskan-Demirag, O., Chen, Y., and Li, J. (2010). Channel coordination under fairness concerns and nonlinear demand. *European Journal of Operational Research*, 207(3):1321–1326.

Camerer, C. and Thaler, R. H. (1995). Anomalies: Ultimatums, dictators and manners. *Journal of Economic Perspectives*, 9(2):209–219.

Camerer, C. F. (1997). Progress in behavioral game theory. *Journal of Economic Perspectives*, 11:167–188.

Campello, F., Delasay, M., Yeo, L., and Schultz, K. L. (2008). Behavioral operations management literature, 2008. In *Behavioral Operations Conference*.

Chang, P.-L. and Lin, C.-T. (1991). On the effect of centralization on expected costs in a multi-location newsboy problem. *Journal of the Operational Research Society*, 42(11):1025–1030.

Chapais, B. (1991). Primates and the origins of aggression, power and politics among humans. *Understanding behavior: What primate studies tell us about human behavior*, pages 190–218.

Charness, G. and Rabin, M. (2002). Understanding social preferences with simple tests. *Quarterly Journal of Economics*, 117(3):817–869.

Chen, F. (2003). Information sharing and supply chain coordination. *Handbooks in operations research and management science*, 11:341–421.

Chen, M.-S. and Lin, C.-T. (1989). Effects of centralization on expected costs in a multi-location newsxboy problem. *Journal of the Operational Research Society*, 40(6):597–602.

Cheng, L., Wan, Z., and Wang, G. (2009). Bilevel newsvendor models considering retailer with cvar objective. *Computers & Industrial Engineering*, 57(1):310–318.

Cherikh, M. et al. (2000). On the effect of centralisation on expected profits in a multi-location newsboy problem. *Journal of the Operational Research Society*, 51(6):755–761.

Chiu, C.-H. and Choi, T.-M. (2010). Optimal pricing and stocking decisions for newsvendor problem with value-at-risk consideration. *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on*, 40(5):1116–1119.

Choi, S. and RuszczyńSki, A. (2008). A risk-averse newsvendor with law invariant coherent measures of risk. *Operations Research Letters*, 36(1):77–82.

Choi, S., Ruszczynski, A., and Zhao, Y. (2011). A multiproduct risk-averse newsvendor with law-invariant coherent measures of risk. *Operations Research*, 59(2):346–364.

Chung, C.-S., Flynn, J., and Kirca, Ö. (2008). A multi-item newsvendor problem with preseason production and capacitated reactive production. *European Journal of Operational Research*, 188(3):775–792.

Ciarallo, F. W., Akella, R., and Morton, T. E. (1994). A periodic review, production planning model with uncertain capacity and uncertain demand—optimality of extended myopic policies. *Management Science*, 40(3):320–332.

Clark, A. E. and Oswald, A. J. (1996). Satisfaction and comparison income. *Journal of public economics*, 61(3):359–381.

Corbett, C. J. and Tang, C. S. (1999). Designing supply contracts: Contract type and information asymmetry. In *Quantitative models for supply chain management*, pages 269–297. Springer.

Corneo, G. and Jeanne, O. (1997). On relative wealth effects and the optimality of growth. *Economics Letters*, 54(1):87–92.

Corneo, G. and Jeanne, O. (2001a). On relative-wealth effects and long-run growth. *Research in Economics*, 55(4):349–358.

Corneo, G. and Jeanne, O. (2001b). Status, the distribution of wealth, and growth. *Scandinavian Journal of Economics*, 103(2):283–293.

Cox, J. C. (2001). On the economics of reciprocity. Working paper, University of Arizona. available online at `http://econ.eller.arizona.edu/docs/Working\_Papers/reciprocity.pdf`.

Cox, J. C. and Deck, C. A. (2005). On the nature of reciprocal motives. *Economic Inquiry*, 43(3):623–635.

Crawford, V. P. (1982). A theory of disagreement in bargaining. *Econometrica: Journal of the Econometric Society*, pages 607–637.

Cui, T., Raju, J., and Zhang, Z. (2007). Fairness and channel coordination. *Management Science*, 53(8):1303–1314.

Cummings, J. (1899). The theory of the leisure class. *Journal of Political Economy*, 7(4):425–455.

DAS, B. and MAITI, M. (2007). An application of bi-level newsboy problem in two substitutable items under capital cost. *Applied Mathematics and Computation*, 190(1):410–422.

Dash Wu, D. (2011). Bargaining in supply chain with price and promotional effort dependent demand. *Mathematical and Computer Modelling*.

de Bruyn, A. and Bolton, G. (2008). Estimating the influence of fairness on bargaining behavior. *Management Science*, 54(10):1774–1791.

de Waal, F. (1996). Good natured, the origins of right and wrong in humans and other animals.

Debo, L. (1999). Repeatedly selling to an impatient newsvendor when demand fluctuates: a supergame theoretic framework for co-operation in a supply chain. Technical report, Carnegie Mellon University Working Paper.

Dempe, S. and Schmidt, H. (1996). On an algorithm solving two-level programming problems with nonunique lower level solutions. *Computational Optimization and Applications*, 6(3):227–249.

Deuermeyer, B. L. (1980). A single period model for a multiproduct perishable inventory system with economic substitution. *Naval Research Logistics Quarterly*, 27(2):177–185.

Dolan, R. J. (1987). Quantity discounts: Managerial issues and research opportunities. *Marketing Science*, 6(1):1–22.

Du, S., Ma, F., Fu, Z., Zhu, L., and Zhang, J. (2011). Game-theoretic analysis for an emission-dependent supply chain in a 'cap-and-trade' system. *Annals of Operations Research, available online at http://dx.doi.org/10.1007/s10479-011-0964-6*.

Duesenberry, J. S. (1949). Income, saving, and the theory of consumer behavior.

Dufwenberg, M. and Kirchsteiger, G. (2004). A theory of sequential reciprocity. *Games and Economic Behavior*, 47(2):268–298.

Easterlin, R. (1973). Does money buy happiness. *Public Interest*, (30):3–10.

Easterlin, R. A. (1974). Does economic growth improve the human lot? some empirical evidence. *Nations and households in economic growth*, 125.

Easterlin, R. A. (1995). Will raising the incomes of all increase the happiness of all? *Journal of Economic Behavior & Organization*, 27(1):35–47.

Edgeworth, F. Y. (1888). The mathematical theory of banking. *Journal of the Royal Statistical Society*, 51(1):113–127.

Eeckhoudt, L., Gollier, C., and Schlesinger, H. (1995). The risk-averse (and prudent) newsboy. *Management Science*, 41(5):786–794.

Ehrhardt, R. and Taube, L. (1987). An inventory model with random replenishment quantities. *International Journal of Production Research*, 25(12):1795–1803.

Ellis, C. J. and Fender, J. (1985). Wage bargaining in a macroeconomic model with rationing. *Quarterly Journal of Economics*, 100(3):625–650.

Emerson, R. M. (1962). Power-dependence relations. *American Sociological Review*, pages 31–41.

Engelmann, D. and Strobel, M. (2004). Inequality aversion, efficiency, and maximin preferences in simple distribution experiments. *American Economic Review*, 94(4):857–869.

Ensel, W. M. (1979). *Sex, social ties and status attainment*. PhD thesis, State University of New York at Albany.

Eppen, G. D. and Iyer, A. V. (1997). Backup agreements in fashion buying: the value of upstream flexibility. *Management Science*, 43(11):1469–1484.

Falk, A., Fehr, E., and Fischbacher, U. (2003). On the nature of fair behavior. *Economic Inquiry*, 41(1):20–26.

Falk, A., Fehr, E., and Fischbacher, U. (2008). Testing theories of fairness—intentions matter. *Games and Economic Behavior*, 62(1):287–303.

Falk, A. and Fischbacher, U. (2006). A theory of reciprocity. *Games and Economic Behavior*, 54(2):293–315.

Fehr, E. and Gächter, S. (2000). Fairness and retaliation: The economics of reciprocity. *Journal of Economic Perspectives*, 14(3):159–181.

Fehr, E., Kirchsteiger, G., and Riedl, A. (1993). Does fairness prevent market clearing? an experimental investigation. *Quarterly Journal of Economics*, 108(2):437–459.

Fehr, E. and Schmidt, K. (1999). A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics*, 114(3):817–868.

Fehr, E. and Schmidt, K. M. (2006). The economics of fairness, reciprocity and altruism – experimental evidence and new theories. In Kolm, S. and Ythier, J. M., editors, *Handbook of the Economics of Giving, Altruism and Reciprocity*, volume 1, pages 615–691. Elsevier, 1 edition.

Feng, Y. and Gallego, G. (1995). Optimal starting times for end-of-season sales and optimal stopping times for promotional fares. *Management Science*, 41(8):1371–1391.

Fershtman, C. and Weiss, Y. (1997). Why do we care what other people think about us. *Economics, values, and organization*, pages 133–150.

Fershtman, C. and Weiss, Y. (1998). Social rewards, externalities and stable preferences. *Journal of Public Economics*, 70(1):53–73.

Festinger, L. (1954). A theory of social comparison processes. *Human relations*, 7(2):117–140.

Fisher, W. H. (2004). Status preference, wealth and dynamics in the open economy. *German Economic Review*, 5(3):335–355.

Fisher, W. H. and Hof, F. X. (2000). Relative consumption, economic growth, and taxation. *Journal of Economics*, 72(3):241–262.

Forsythe, R., Horowitz, J. L., Savin, N. E., and Sefton, M. (1994). Fairness in simple bargaining experiments. *Games and Economic behavior*, 6(3):347–369.

Frank, R. H. (1984). Interdependent preferences and the competitive wage structure. *RAND Journal of Economics*, 15(4):510–520.

Frank, R. H. (1985). The demand for unobservable and other nonpositional goods. *American Economic Review*, 75(1):101–16.

Frank, R. H. (1997). The frame of reference as a public good. *Economic Journal*, 107(445):1832–1847.

Frank, R. H. (1999). *Luxury fever*. New York: The Free Press.

Frazier, G. (1983). Interorganizational exchange behavior in marketing channels: a broadened perspective. *Journal of Marketing*, 47(4):68–78.

Futagami, K. and Shibata, A. (1998). Keeping one step ahead of the joneses: status, the distribution of wealth, and long run growth. *Journal of Economic Behavior & Organization*, 36(1):109–126.

Gallego, G. and Moon, I. (1993). The distribution free newsboy problem: review and extensions. *Journal of the Operational Research Society*, 44:825–834.

Geanakoplos, J., Pearce, D., and Stacchetti, E. (1989). Psychological games and sequential rationality. *Games and Economic Behavior*, 1(1):60–79.

Gerchak, Y. and Wang, Y. (1994). Periodic-review inventory models with inventory-level-dependent demand. *Naval Research Logistics (NRL)*, 41(1):99–116.

Gerchak, Y. and Zhang, X. (1992). The effect of initial inventories in a two-echelon system. *IIE transactions*, 24(1):64–69.

Gertler, M. and Trigari, A. (2006). Unemployment fluctuations with staggered nash wage bargaining. Technical report, National Bureau of Economic Research.

Gilboa, I. and Schmeidler, D. (1988). Information dependent games: Can common sense be common knowledge? *Economics Letters*, 27(3):215–221.

Gino, F. and Pisano, G. (2008). Toward a theory of behavioral operations. *Manufacturing & Service Operations Management*, 10(4):676–691.

Grossmann, V. (1998). Are status concerns harmful for growth? *FinanzArchiv/Public Finance Analysis*, pages 357–373.

Grout, P. A. (1984). Investment and wages in the absence of binding contracts: A nash bargaining approach. *Econometrica: Journal of the Econometric Society*, pages 449–460.

Güth, W. (1995). On ultimatum bargaining experiments–a personal review. *Journal of Economic Behavior & Organization*, 27(3):329–344.

Güth, W., Huck, S., and Müller, W. (1998). The relevance of equal splits: On a behavioral discontinuity in ultimatum games. Technical report, Discussion Papers, Interdisciplinary Research Project 373: Quantification and Simulation of Economic Processes.

Güth, W., Schmittberger, R., and Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior & Organization*, 3(4):367–388.

Harbaugh, R. (1996). Falling behind the joneses: relative consumption and the growth-savings paradox. *Economics Letters*, 53(3):297–304.

He, X., Prasad, A., Sethi, S. P., and Gutierrez, G. J. (2007). A survey of stackelberg differential game models in supply and marketing channels. *Journal of Systems Science and Systems Engineering*, 16(4):385–413.

Henig, M. and Gerchak, Y. (1990). The structure of periodic review policies in the presence of random yield. *Operations Research*, 38(4):634–643.

Hill, R. M. (1997). Applying bayesian methodology with a uniform prior to the single period inventory model. *European Journal of Operational Research*, 98(3):555–562.

Ho, T. and Su, X. (2009). Peer-induced fairness in games. *American Economic Review*, 99(5):2022–2049.

Ho, T. and Zhang, J. (2008). Designing pricing contracts for boundedly rational customers: Does the framing of the fixed fee matter. *Management Science*, 54(4):686–700.

Ho, T.-H., Lim, N., and Cui, T. H. (2010). Reference dependence in multilocation newsvendor models: A structural analysis. *Management Science*, 56(11):1891–1910.

Ho, T.-H., Su, X., and Wu, Y. (2013). Distributional and peer-induced fairness in supply chain contract design. *Production and Operations Management*, 23(2):161–175.

Hof, F. X. and Wirl, F. (2003). Wealth induced multiple equilibria in small open economy versions of the ramsey model. Technical report, mimeo.

Homan, G. C. (1950). The human group. *New York*.

Hsiao, J. and Lin, C. (2005). A buyer-vendor eoq model with changeable lead-time in supply chain. *International Journal of Advanced Manufacturing Technology*, 26(7-8):917–921.

Huang, P. H. (2000). Reasons within passions: Emotions and intentions in property rights bargaining. *Oregon Law Review*, 79(2):435–478.

Huang, Z. and Li, S. (2001). Co-op advertising models in manufacturer–retailer supply chains: A game theory approach. *European Journal of Operational Research*, 135(3):527–544.

Huberman, B. A., Loch, C. H., and Önçüler, A. (2004). Status as a valued resource. *Social Psychology Quarterly*, 67(1):103–114.

Jaeger, W. K. (2004). Status seeking and social welfare: Is there virtue in vanity? *Social science quarterly*, 85(2):361–379.

Jammernegg, W. and Kischka, P. (2007). Risk-averse and risk-taking newsvendors: a conditional expected value approach. *Review of Managerial Science*, 1(1):93–110.

Jeuland, A. and Shugan, S. (1983). Managing channel profits. *Marketing Science*, 2(3):239–272.

Jönsson, H., Jörnsten, K., and Silver, E. A. (1993). Application of the scenario aggregation approach to a two-stage, stochastic, common component, inventory problem with a budget constraint. *European Journal of Operational Research*, 68(2):196–211.

Jucker, J. V. and Rosenblatt, M. J. (1985). Single-period inventory models with demand uncertainty and quantity discounts: Behavioral implications and a new solution procedure. *Naval Research Logistics Quarterly*, 32(4):537–550.

Kahneman, D., Knetsch, J. L., and Thaler, R. H. (1986a). Fairness and the assumptions of economics. *Journal of Business*, 59(4):S285–S300.

Kahneman, D., Knetsch, J. L., and Thaler, R. H. (1986b). Fairness as a constraint on profit seeking: Entitlements in the market. *American Economic Review*, 76(4):728–741.

Katok, E. (2011). Laboratory experiments in operations management. In Geunes, J., editor, *TutORials in Operations Research*, pages 15–35. INFORMS.

Katok, E. and Pavlov, V. (2013). Fairness in supply chain contracts: A laboratory study. *Journal of Operations Management*, 31(3):129–137.

Kawamoto, K. (2009). Status-seeking behavior, the evolution of income inequality, and growth. *Economic Theory*, 39(2):269–289.

Kemper, T. D. and Collins, R. (1990). Dimensions of microinteraction. *American Journal of Sociology*, 96(1):32.

Khouja, M. (1995). The newsboy problem under progressive multiple discounts. *European Journal of Operational Research*, 84(2):458–466.

Khouja, M. (1996). The newsboy problem with progressive retailer discounts and supplier quantity discounts. *Decision Sciences*, 27:589–599.

Khouja, M. (1999). The single-period (news-vendor) problem: literature review and suggestions for future research. *Omega*, 27(5):537–553.

Khouja, M. and Mehrez, A. (1996). A multi-product constrained newsboy problem with progressive multiple discounts. *Computers & Industrial Engineering*, 30(1):95–101.

Khouja, M., Park, S., and Zhou, J. (2013). A free gift card alternative to price discounts in the newsvendor problem. *Omega*, 41(4):665–678.

Khouja, M. and Robbins, S. S. (2003). Linking advertising and quantity decisions in the single-period inventory model. *International Journal of Production Economics*, 86(2):93–105.

Kicsiny, R., Varga, Z., and Scarelli, A. (2014). Backward induction algorithm for a class of closed-loop stackelberg games. *European Journal of Operational Research*.

Kirchsteiger, G., Fehr, E., and Gächter, S. (1996). Reciprocal fairness and noncompensating wage differentials. *Journal of Institutional and Theoretical Economics*, 152(4):608–640.

Kocabiyikoglu, A. and Popescu, I. (2011). An elasticity approach to the newsvendor with price-sensitive demand. *Operations Research*, 59(2):301–312.

Kodama, M. (1995). Probabilistic single period inventory model with partial returns and additional orders. *Computers & Industrial Engineering*, 29(1):455–459.

Kohler, S. (2003). Difference aversion and surplus concern-an integrated approach.

Kolpin, V. (1992). Equilibrium refinement in psychological games. *Games and Economic Behavior*, 4(2):218–231.

Konrad, K. and Lommerud, K. (1993). Relative standing comparisons, risk taking, and safety regulations. *Journal of Public Economics*, 51(3):345–358.

Korth, C. (2009). *Fairness in bargaining and markets*. Springer.

Kouvelis, P. and Gutierrez, G. J. (1997). The newsvendor problem in a global market: Optimal centralized and decentralized control policies for a two-market stochastic inventory system. *Management Science*, 43(5):571–585.

Krishnan, H., Kapuscinski, R., and Butz, D. A. (2004). Coordinating contracts for decentralized supply chains with retailer promotional effort. *Management Science*, 50(1):48–63.

Kumar, N. (1996). The power of trust in manufacturer-retailer relationships. *Harvard business review*, 74(6):92.

Kumaran, M. and Achary, K. (1996). On approximating lead time demand distributions using the generalised λ-type distribution. *Journal of the Operational Research Society*, 47(3):395–404.

Lafontaine, F. and Slade, M. E. (2001). *Incentive contracting and the franchise decision*. Springer.

Lanzillotti, R. F. (1958). Pricing objectives in large companies. *American Economic Review*, 48(5):921–940.

Lariviere, M. A. (1999). Supply chain contracting and coordination with stochastic demand. In *Quantitative models for supply chain management*, pages 233–268. Springer.

Lariviere, M. A. and Porteus, E. L. (2001). Selling to the newsvendor: An analysis of price-only contracts. *Manufacturing & Service Operations Management*, 3(4):293–305.

Lau, A. H.-L. and Lau, H.-S. (1988). The newsboy problem with price-dependent demand distribution. *IIE transactions*, 20(2):168–175.

Lau, H.-S. (1997). Simple formulas for the expected costs in the newsboy problem: An educational note. *European Journal of Operational Research*, 100(3):557–561.

Lau, H.-S. and Hing-Ling Lau, A. (1995). The multi-product multi-constraint newsboy problem: Applications, formulation and solution. *Journal of Operations Management*, 13(2):153–162.

Lau, H.-S. and Hing-Ling Lau, A. (1996). The newsstand problem: A capacitated multiple-product single-period inventory problem. *European Journal of Operational Research*, 94(1):29–42.

Leibenstein, H. (1950). Bandwagon, snob, and veblen effects in the theory of consumers' demand. *Quarterly Journal of Economics*, 64(2):183–207.

Leitmann, G. (1978). On generalized stackelberg strategies. *Journal of Optimization Theory and Applications*, 26(4):637–643.

Levine, D. K. (1998). Modeling altruism and spitefulness in experiments. *Review of Economic Dynamics*, 1(3):593–622.

Li, J., Lau, H.-S., and Lau, A. H.-L. (1991). A two-product newsboy problem with satisficing objective and independent exponential demands. *IIE transactions*, 23(1):29–39.

Lignola, M. and Morgan, J. (1995). Topological existence and stability for stackelberg problems. *Journal of Optimization Theory and Applications*, 84(1):145–169.

Lignola, M. and Morgan, J. (1997). Stability of regularized bilevel programming problems. *Journal of Optimization Theory and Applications*, 93(3):575–596.

Lin, C., Chen, C., and Hsieh, H. (2001). Effects of centralization on expected profits in a multi-location newsboy problem. *Journal of the Operational Research Society*, 52(7):839–841.

Lin, C.-S. and Kroll, D. E. (1997). The single-item newsboy problem with dual performance measures and quantity discounts. *European Journal of Operational Research*, 100(3):562–565.

Lippman, S. A. and McCardle, K. F. (1997). The competitive newsboy. *Operations Research*, 45(1):54–65.

Liu, W., Song, S., and Wu, C. (2013). Impact of loss aversion on the newsvendor game with product substitution. *International Journal of Production Economics*, 141(1):352–359.

Ljungqvist, L. and Uhlig, H. (2000). Tax policy and aggregate demand management under catching up with the joneses. *American Economic Review*, 90(3):356–366.

Loch, C. and Wu, Y. (2008). Social preferences and supply chain performance: An experimental study. *Management Science*, 54(11):1835–1849.

Loch, C. H., Huberman, B. A., and Stout, S. (2000). Status competition and performance in work groups. *Journal of Economic Behavior & Organization*, 43(1):35–55.

Loch, C. H. and Wu, Y. (2007). Behavioral operations management. *Foundations and Trends (R) in Technology, Information and Operations Management*, 1(3):121–232.

Loewenstein, G. F., Thompson, L., and Bazerman, M. H. (1989). Social utility and decision making in interpersonal contexts. *Journal of Personality and Social psychology*, 57(3):426–441.

Loridan, P. and Morgan, J. (1989). New results on approximate solution in two-level optimization. *Optimization*, 20(6):819–836.

Loridan, P. and Morgan, J. (1992). Regularizations for two-level optimization problems. In *Advances in optimization*, pages 239–255. Springer.

Loridan, P. and Morgan, J. (1996). Weak via strong stackelberg problem: New results. *Journal of Global Optimization*, 8(3):263–287.

Luh, P. B., Chang, S.-C., and Chang, T.-S. (1984). Solutions and properties of multi-stage stackelberg games. *Automatica*, 20(2):251–256.

Ma, L., Zhao, Y., Xue, W., Cheng, T., and Yan, H. (2012). Loss-averse newsvendor model with two ordering opportunities and market information updating. *International Journal of Production Economics*, 140(2):912–921.

Macneil, I. (1980). Power, contract, and the economic model. *Journal of Economic Issues*, 14(4):909–923.

Marsden, P. V. and Hurlbert, J. S. (1988). Social resources and mobility outcomes: A replication and extension. *Social forces*, 66(4):1038–1059.

Marwell, G. and Ames, R. E. (1979). Experiments on the provision of public goods. i. resources, interest, group size, and the free-rider problem. *American Journal of sociology*, 84(6):1335–1360.

Matsuo, H. (1990). A stochastic sequencing problem for style goods with forecast revisions and hierarchical structure. *Management Science*, 36(3):332–347.

Mazumdar, R., Mason, L. G., and Douligeris, C. (1991). Fairness in network optimal flow control: Optimality of product forms. *Communications, IEEE Transactions on*, 39(5):775–782.

McCabe, K. A., Rassenti, S. J., and Smith, V. L. (1998). Reciprocity, trust, and payoff privacy in extensive form bargaining. *Games and Economic Behavior*, 24(1):10–24.

McCabe, K. A. and Smith, V. L. (2000). A comparison of naïve and sophisticated subject behavior with game theoretic predictions. *Proceedings of the National Academy of Sciences*, 97(7):3777–3781.

McDonald, I. M. and Solow, R. M. (1981). Wage bargaining and employment. *American Economic Review*, pages 896–908.

Molodtsov, D. (1976). The solution of a class of non-antagonistic games. *USSR Computational Mathematics and Mathematical Physics*, 16(6):67–72.

Monahan, J. P. (1984). A quantity discount pricing model to increase vendor profits. *Management science*, 30(6):720–726.

Moorthy, K. S. (1987). Comment-managing channel profits: Comment. *Marketing Science*, 6(4):375–379.

Moritz, B. B., Hill, A. V., and Donohue, K. L. (2013). Individual differences in the newsvendor problem: Behavior and cognitive reflection. *Journal of Operations Management*, 31(1):72–85.

Mortensen, D. T. and Pissarides, C. A. (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies*, 61(3):397–415.

Moulin, H. (1984). Implementing the kalai-smorodinsky bargaining solution. *Journal of Economic Theory*, 33(1):32–45.

Munson, C. L. and Rosenblatt, M. J. (2001). Coordinating a three-level supply chain with quantity discounts. *IIE transactions*, 33(5):371–384.

Nalebuff, B. and Shubik, M. (1988). Revenge and rational play. Technical report.

Nash, J. F. (1950). The bargaining problem. *Econometrica*, 18(2):155–162.

Nash, J. F. (1953). Two-person cooperative games. *Econometrica*, 21(1):128–140.

Nelson, J. W. R. (2002). Equity or intention: it is the thought that counts. *Journal of Economic Behavior & Organization*, 48(4):423–430.

Nie, P.-y. (2005). Dynamic stackelberg games under open-loop complete information. *Journal of the Franklin Institute*, 342(7):737–748.

Normann, H.-T. (1997). Endogenous stackelberg equilibria with incomplete information. *Journal of economics*, 66(2):177–187.

Offerman, T. (2002). Hurting hurts more than helping helps. *European Economic Review*, 46(8):1423–1437.

Okuno-Fujiwara, M. and Postlewaite, A. (1995). Social norms and random matching games. *Games and Economic behavior*, 9(1):79–109.

Olmstead, A. L. and Rhode, P. (1985). Rationing without government: The west coast gas famine of 1920. *American economic review*, 75(5):1044–1055.

Osborne, M. J. and Rubinstein, A. (1994). *A course in game theory*. MIT press.

Oswald, A. J. (1997). Happiness and economic performance. *Economic Journal*, 107(445):1815–1831.

Özler, A., Tan, B., and Karaesmen, F. (2009). Multi-product newsvendor problem with value-at-risk considerations. *International Journal of Production Economics*, 117(2):244–255.

Pantumsinchai, P. and Knowles, T. W. (1991). Standard container size discounts and the single-period inventory problem. *Decision Sciences*, 22(3):612–619.

Parlar, M. (1988). Game theoretic analysis of the substitutable product inventory problem with random demands. *Naval Research Logistics (NRL)*, 35(3):397–409.

Parlar, M. and Wang, D. (1993). Diversification under yield randomness in inventory models. *European Journal of Operational Research*, 66(1):52–64.

Pasternack, B. A. (1985). Optimal pricing and return policies for perishable commodities. *Marketing Science*, 4(2):166–176.

Pavlov, V. and Katok, E. (2009). Fairness and coordination failures in supply chain contracts. Working paper, University of Texas at Dallas. available online at `http://www.utdallas.edu/\~{}ekatok/fair\_theory.pdf`.

Perretti, F. and Negro, G. (2006). Filling empty seats: How status and organizational hierarchies affect exploration versus exploitation in team design. *Academy of Management Journal*, 49(4):759–777.

Persson, M. (1995). Why are taxes so high in egalitarian societies? *Scandinavian Journal of Economics*, pages 569–580.

Pfeifer, P. E. (1989). The airline discount fare allocation problem. *Decision Sciences*, 20(1):149–157.

Pollak, R. A. (1976). Interdependent preferences. *American Economic Review*, 66(3):309–320.

Postlewaite, A. (1998). The social basis of interdependent preferences. *European Economic Review*, 42(3-5):779–800.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *American Economic Review*, 83(5):1281–1302.

Rachmilevitch, S. (2011). Fairness, efficiency, and the nash bargaining solution. *University of Haifa, Department of Economics Working Papers*.

Rauscher, M. (1997a). Protestant ethic, status seeking, and economic growth. Technical report, Thünen-Series of Applied Economic Theory.

Rauscher, M. (1997b). Conspicuous consumption, economic growth, and taxation. *Journal of Economics*, 66(1):35–42.

Reinhard, S. (1965). Spieltheoretische behandlung eines oligopolmodells mit nachfrageträgheit. teil i: Bestimmung des dynamischen preisgleichgewichts; teil ii: Eigenschaften des dynamischen preisgleichgewichts. *Zeitschrift für die gesamte Staatswissenschaft*, 121:301–324 and 667–689.

Ren, Y. and Croson, R. (2013). Overconfidence in newsvendor orders: An experimental study. *Management Science*, 59(11):2502–2517.

Ridder, A., Van Der Laan, E., and Salomon, M. (1998). How larger demand variability may lead to lower costs in the newsvendor problem. *Operations Research*, 46(6):934–936.

Ridgeway, C. L. and Walker, H. A. (1995). Status structures. *Sociological perspectives on social psychology*, pages 281–310.

Rosenblatt, M. J. and Lee, H. L. (1985). Improving profitability with quantity discounts under fixed demand. *IIE transactions*, 17(4):388–395.

Roth, A. E. (1985). A note on risk aversion in a perfect equilibrium model of bargaining. *Econometrica: Journal of the Econometric Society*, pages 207–211.

Roth, A. E. and Erev, I. (1995). Learning in extensive-form games: Experimental data and simple dynamic models in the intermediate term. *Games and economic behavior*, 8(1):164–212.

Rubinstein, A. (1982). Perfect equilibrium in a bargaining model. *Econometrica*, 50(1):97–109.

Ruffle, B. (1998). More is better, but fair is fair: Tipping in dictator and ultimatum games. *Games and Economic Behavior*, 23(2):247–265.

Scheer, L. K., Kumar, N., and Steenkamp, J.-B. E. (2003). Reactions to perceived inequity in us and dutch interorganizational relationships. *Academy of Management Journal*, 46(3):303–316.

Schweitzer, M. E. and Cachon, G. P. (2000). Decision bias in the newsvendor problem with a known demand distribution: Experimental evidence. *Management Science*, 46(3):404–420.

Sholokho, V. (1970). Unstable extremal problems and geometric properties of banach spaces. *Doklady Akademii Nauk SSSR*, 195(2):289.

Shrimali, G., Akella, A., and Mutapcic, A. (2010). Cooperative interdomain traffic engineering using nash bargaining and decomposition. *IEEE/ACM Transactions on Networking (TON)*, 18(2):341–352.

Simaan, M. and Cruz Jr, J. B. (1973). On the stackelberg strategy in nonzero-sum games. *Journal of Optimization Theory and Applications*, 11(5):533–555.

Spengler, J. J. (1950). Vertical integration and antitrust policy. *Journal of Political Economy*, pages 347–352.

Stanca, L. (2010). How to be kind? outcomes versus intentions as determinants of fairness. *Economics letters*, 106(1):19–21.

Su, X. (2008). Bounded rationality in newsvendor models. *Manufacturing & Service Operations Management*, 10(4):566–589.

Sutter, M. (2007). Outcomes versus intentions: On the nature of fair behavior and its development with age. *Journal of Economic Psychology*, 28(1):69–78.

Taylor, T. A. (2002). Supply chain coordination under channel rebates with sales effort effects. *Management Science*, 48(8):992–1007.

Thaler, R. H. (1988). Anomalies: The ultimatum game. *Journal of Economic Perspectives*, 2(4):195–206.

Thye, S. R. (2000). A status value theory of power in exchange relations. *American Sociological Review*, pages 407–432.

Tomlin, B. (2003). Capacity investments in supply chains: Sharing the gain rather than sharing the pain. *Manufacturing & Service Operations Management*, 5(4):317–333.

Touati, C., Altman, E., and Galtier, J. (2006). Generalized nash bargaining solution for bandwidth allocation. *Computer Networks*, 50(17):3242–3263.

Tsay, A. A., Nahmias, S., and Agrawal, N. (1999). Modeling supply chain contracts: A review. In *Quantitative models for supply chain management*, pages 299–336. Springer.

Von Stackelberg, H. (1952). *The theory of the market economy*. William Hodge.

Wang, C. X. and Webster, S. (2009). The loss-averse newsvendor problem. *Omega*, 37(1):93–105.

Wang, Q. (2001). Coordinating independent buyers in a distribution system to increase a vendor's profits. *Manufacturing & Service Operations Management*, 3(4):337–348.

Wang, Q. (2002). Determination of suppliers' optimal quantity discount schedules with heterogeneous buyers. *Naval Research Logistics (NRL)*, 49(1):46–59.

Wang, Q. (2004). Coordinating independent buyers with integer-ratio time coordination and quantity discounts. *Naval Research Logistics (NRL)*, 51(3):316–331.

Wang, T., Atasu, A., and Kurtulus, M. (2012). A multiordering newsvendor model with dynamic forecast evolution. *Manufacturing & Service Operations Management*, 14(3):472–484.

Ward, S., Chapman, C., and Klein, J. (1991). Theoretical versus applied models: the newsboy problem. *Omega*, 19(4):197–206.

Weatherford, L. and Pfeifer, P. (1994). The economic value of using advance booking of orders. *Omega*, 22(1):105–111.

Weng, Z. K. (1995). Channel coordination and quantity discounts. *Management science*, 41(9):1509–1522.

Whang, S. (1995). Coordination in operations: a taxonomy. *Journal of Operations Management*, 12(3):413–422.

Wilson, R. (1997). Nonlinear pricing. *OUP Catalogue*.

Wu, D., Baron, O., and Berman, O. (2009a). Bargaining in competing supply chains with uncertainty. *European Journal of Operational Research*, 197(2):548–556.

Wu, J., Li, J., Wang, S., and Cheng, T. (2009b). Mean–variance analysis of the newsvendor model with stockout cost. *Omega*, 37(3):724–730.

Xu, M. and Lu, Y. (2013). The effect of supply uncertainty in price-setting newsvendor models. *European Journal of Operational Research*, 227(3):423–433.

Yaïche, H., Mazumdar, R. R., and Rosenberg, C. (2000). A game theoretic framework for bandwidth allocation and pricing in broadband networks. *IEEE/ACM Transactions on Networking (TON)*, 8(5):667–678.

Yu, Y., Chu, F., and Chen, H. (2009a). A stackelberg game and its improvement in a vmi system with a manufacturing vendor. *European Journal of Operational Research*, 192(3):929–948.

Yu, Y., Huang, G. Q., and Liang, L. (2009b). Stackelberg game-theoretic model for optimizing advertising, pricing and inventory policies in vendor managed inventory (vmi) production supply chains. *Computers & Industrial Engineering*, 57(1):368–382.