CHANNEL COORDINATION MECHANISM WITH RETAILERS HAVING FAIRNESS PREFERENCE
—AN IMPROVED QUANTITY DISCOUNT MECHANISM

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ABSTRACT. Channel coordination is an optimal state with operation of channel. For achieving channel coordination, we present a quantity discount mechanism based on a fairness preference theory. Game models of the channel discount mechanism are constructed based on the entirely rationality and self-interest. The study shows that as long as the degree of attention (parameters) of retailer to manufacturer’s profit and the fairness preference coefficients (parameters) of retailers satisfy certain conditions, channel coordination can be achieved by setting a simple wholesale price and fixed costs. We also discuss the allocation method of channel coordination profit, the allocation method ensure that retailer’s profit is equal to the profit of independent decision-making, and manufacturer’s profit is raised.

1. Introduction. Aamoco’s franchisees predicted that with the increase of maintenance guarantee offered by vehicle manufacturers, their business will become more and more difficult. The franchisees eagerly required to decrease the rate of royalty from 9% to 5% and in the meantime, expand their business area. However, Aamoco hoped to increase the rate of royalty. An intense channel conflict happened due to the disparity of the two goals [33]. Finally, the conflict leads to both profit was damaged. If there is price mechanism to promote their coordination, both sides can obtain more profit. The conflict between GREE and GOME in 2004 showed that both retailers and manufacturers in the channel wanted to compete for the controlling power. The lack of coordination led to damage in profits of both sides. GOME and GREE also found that conflicts in the past few years resulted in a detriment to their profits. Therefore, they shook hands in 2007[34]. These two simple cases illustrate that, in practice, channels are easily in conflict. How to avoid channel conflicts and achieve channel coordination is an important issues.

In fact, whether channel manufacturers should coordinate with the retailers or sell products in general distribution channels has always been a focus. McGuire
and Staelin [21, 20] carried out a systematic study in channel’s competition and coordination, which mainly reflected two aspects. First, whether the manufacturer’s distribution channels should manage with vertical integration or decentralization management. Second, whether the manufacturers should provide incentive mechanism in order to improve the coordination between channel members. Jeuland and Shugan [15] studied the problem of the channel coordination between a single manufacturer and a single retailer. They believe that if there isn’t proper incentive between the channel members, channel members will not collaborate or coordinate instinctively. They deduce that vertical integration allows channel to achieve maximized profits. However, this is not the only way. We can also use contract, implicit understandings, profit sharing and quantity discounts to incentive coordination. Coughlan [6] discusses the problem of choosing a vertical marketing channel in a product-differentiated duopolistic market. Firms choose product price and the form of the marketing channel to maximize profits. It is shown that integration of the marketing function results in greater price competition and lower prices than does the use of independent marketing middlemen. They also conducted an empirical study on the semiconductor industry. Chen [5] studies the cooperation problem from the perspective of buyers’ cooperative strategy. Shen [26] discusses integrated supply chain’s a survey and future research directions. (Other discuss see [31, 32, 29, 27, 3]).

The above scholars have a same goal. They hope to design some mechanisms or contracts to promote the coordination between manufacturers and retailers. These mechanisms include quantity discount mechanism (see [15]), the two-part tariff, three-part tariff and some other complex contractual mechanisms. Although these mechanisms can achieve channel coordination in theory, it is very difficult to use them in practice. Holmstrom and Milgrom [12] postulates that a simple contract is always the optimal contract in reality. Furthermore, these contractual mechanisms are based on a basic assumption: manufacturers and retailers are entirely rational. It means that manufacturers and retailers make decisions based on the maximization of their own profits. Ultimatum game, dictator game, gift exchange game and trust game showed that not all the behaviors of channel members can be explained by the theory of utility-maximizing in neo-classical economics. These explanations are sometimes inconsistent with the “real world” because in practice, deciders will consider both a self-interest and an altruism (see [23, 4, 10]). Arrow [1], Samuelson [24] and Sen [25] pointed out that, in reality, people would be with limited rationality. They also care about the interests of others and the fairness of the material interests distribution. Kahneman et al. [16] considered that, like an individual, a company would also concern about fairness in front of some important events in business relationships (including channel relationships). Fairness plays an important role in establishing and maintaining channel relationships. This is actually a problem of fairness preference theory in behavioral economics\(^2\). Using the fairness

\(^2\)Based on the framework “Psychological game” which J.Geanakoplos, D.Pearce and E.Stacchetti(called GPS for short in literature) established, Rabin [12] had constructed a game theory with introducing fairness preferences theory. He Redefined the payoff function in the traditional game theory through the definition of “fair” concept, then discovered some new “fair balances” – “Cooperative Equilibrium”, The new equilibriums don’t require infinitely repeated games or asymmetric information condition which traditional game theory needs. This result could strongly explain altruism and cooperation phenomenon.
preference theory in channel research, one can reduce the double marginalization\(^3\) and help to achieve coordination (Cui et al [7], Wu and Loch [18]). Therefore, the channels coordination based on fairness preferences theory becomes an important research focus in pricing decisions.

In practise, we find that the manufacturers and retailers concern about whether the final result is fair or not. Manufacturers (retailers) care about the result of material interests, including the material interest distributed to themselves. Their utility function model presented in [12], in which we call fairness preferences based on the result. It is characterized by the assumption that manufacturers (retailers) face a trade-off with retailers (manufacturers). In other words, manufacturers (retailers) must consider carefully between material interests and equitable (equivalent) degree of distribution to achieve the individual utility maximization. If the demand function is linear, as in Cui et al. [7], a simple wholesale price contract under the fairness preference model can attain channel coordination. Ozgun et al. [22] studied the channel coordination problem based on the result fairness preference with an assumption of a non-linear demand function (an exponential function). The experiment of Ho and Zhang [11] found that under the fairness preference the linear efficiency is higher than the efficiency of the two-part contracts.

In this paper, we only study the channel Stackelberg game of manufacturer dominant, according to Fehr and Schmidt [10], Debruyyn and Bolton [8] showed: the decision makers in a weak position are more concerned about the comparative income than other decision makers. Loch, and Wu [18] experiments show that: under normal circumstances, subjects weak position even more concerned about their own benefit and the other is the size. Stackelberg channel game this paper manufacturers dominated, the retailer has a weak position, such as Wei [30] Wang, Hou [28], Du [9], Ma [19], only consider that retailers have the fairness preference, so we only considers fair-minded retailers.

The aim of this work is to apply the fairness preference theory in channel coordination. Firstly, assuming entirely rationality, we will present a quantity discount mechanism which is different from that presented in Jeuland and Shugan [15]. Jeuland and Shugan [15]’s quantity discount mechanism is: a manufacturer who offers the retailer a quantity discount varies the price charged to the retailer according to the quantity purchased by the retailer. The retailer obtains a discount for purchasing a larger quantity of the product from the manufacturer. The larger the quantity purchased, the lower the per unit costs to the retailer (See [15] pages 253). Our quantity discount mechanism is the manufacturer offers each unit product to the retailer with the wholesale price \(w\). Based on the demand quantity, if the purchasing volume of the retailer is \(Q\), the wholesale price given by manufacturer will be \(w - \theta Q (0 \leq \theta \leq \frac{w}{Q})\), where \(\theta\) is called the discount coefficient. That is, our quantity discount mechanism is a linear function with regard to \(Q\). Jeuland and Shugan [15]’s quantity discount mechanism is a non-linear function with regard to \(Q\). See Jeuland and Shugan [15]’s page 253-254. With our simple quantity discount mechanism, we achieve channel coordination. Secondly, we will add the fairness preference into the quantity discount mechanism to study whether the channel can reach coordination with this improved quantity discount mechanism or not. With analysis, as long as the degree of attention (parameters) with retailers to manufacturer’s profit, fairness preference coefficients (parameters) of retailers satisfy certain conditions, by setting

\(^3\)The “double marginalization” is also known as “double plus”. The American economist Spengler’s early study towards analysis of industrial system behavior had been found.
a simple wholesale price and fixed costs, channels of coordination is achieved. Our research method is different from the method of Cui et al. [7]. Cui et al. [7] only consider the fairness preference to achieve coordination, we think that, in practice, the quantity discount is a common incentive method, channel members also have fairness preference, therefore, it is an important significance that the channels coordination is achieved with simultaneously considering the quantity discount and the fairness preference. It should be emphasized that our profit distribution is different from that presented in Cui et al. [7]. Cui et al. [7] shows that the ratio of the channel coordination profit distribution is relevant to the parameter. However the propositions in this paper are that retailer’s profits are equal to the profits of independent decision-making. See Table 3.

This paper is organized as follows. Section 2 gives the notations and the basic hypothesis. Section 3 establishes two models of decision-making channel. One is the channel coordination model and the other is the manufacturer-led decision-making model under non-fairness preference. Section 4 studies how to achieve coordination under the new quantity discount mechanism based on fairness preference theory. Section 5 analyzes the conditions that channel coordination needs, and Section 6 is the conclusion.

2. The integrated channel, the independent channel and the quantity discount contract. In order to facilitate the research, Considering a simple distribution channel consists of one manufacturer and one retailer. The manufacturer is an upstream monopolist in the distribution channel and the retailer is a monopolist seller in the consumer market. The retailer chooses either to sell the products of the manufacturer for profits, or not (with no profit) (see [13, 14, 11]). The manufacturer produces a product at a marginal cost $c$ and offers a wholesale price $w$ to the retailer. The retailer suffers no additional selling costs or charges except the wholesale price, and offers to the consumer with a retail price $p$.

The demand curve is a linear function of retail price $p$: $Q = a - p^4$ where $a$ is the maximum demand and is assumed to be larger than marginal cost $c$. These are common knowledge for both the manufacturer and the retailer.

The profit function of manufacturer is $\pi_M = (w - c)(a - p)$, and the profit function of retailer is $\pi_R = (p - w)(a - p)$. In Table 1, we summarize our model notations for the ease of reference.

2.1. The integrated channel. As the baseline for comparison, without considering the fairness preferences, we first analyze the distribution channel decision model. If the distribution channel is integrated, the manufacturers and the retailers cooperate to maximize the profit of the channel (while the manufacturers take total control of the channel). As a result, we choose the optimal retail price to satisfy

\[ p^I* \in Arg \max_p \pi^I = Arg \max_p (p - c)(a - p). \] (1)

The first order condition of formula (1) is $p^I* = \frac{a + c}{2}$. Then we can obtain the optimal total profit $\pi^{I*}_{Total} = \frac{(a - c)^2}{4}$ and the optimal demand $Q^{I*} = \frac{a - c}{2}$.

\[ 4 \text{In Cui et al. [7], } Q = a - bp, b \text{ is the elasticity coefficient, In order to reduce the complexity of the model, assumption } b=1, \text{ this does not affect the conclusions of this paper.} \]

\[ 5 \text{We can easily judge two order conditions is less than zero, the latter part of this article will use the first-order conditions, but their two order conditions is less than zero, we ensure that the stagnation point is the point of maximum value, we do not individually tested.} \]
Table 1: Variable Definitions

| Notation | Definition |
|----------|------------|
| $c$      | Manufacturers marginal production cost |
| $w$      | wholesale price |
| $p, f$   | Retail price, manufacturer-charged flat fee |
| $Q = a - p$ | Market demand, $a$ is the maximum demand |
| $\pi_M = (w - c)(a - p)$ | Profit functions for manufacturer |
| $\pi_R = (p - w)(a - p)$ | Profit functions for retailer |
| $\alpha$ | Retailers disadvantageous inequality parameters |
| $\beta$ | Retailers advantageous inequality parameters |
| $\text{sgn, sgn}(.)$ | Sign function |
| $\eta$ | Degree of attention (parameters) of retailer to manufacturer’s profit |
| $\theta$ | Discount coefficient |
| $U_R$ | Utility functions for retailer |

2.2. The independent channel. If the channel members are independent (the manufacturer is dominant in distribution channel), the manufacturer and the retailer respectively choose their own prices, $w$ and $p$, to maximize their individual profits. In this game, the manufacturer offers a wholesale price $w$. According to the wholesale price, if the retailer rejects the sale contract, it will lead to zero profits, and the game is over. However, if the retailer accepts the offer, he will make the retail price to maximize his profit according to the given wholesale price $w$. We then get the first order condition (reaction function) of $\pi_R$ ($\pi_R = (p - w)(a - p)$) is $p^* = \frac{a + w}{2}$ by backward induction. We put $p^* = \frac{a + w}{2}$ into the profit function of manufacturer and get a result of $\pi_M = \frac{(w - c)(a - w)}{2}$. We further have the optimal wholesale price $w^* = \frac{a + w}{2}$. Therefore, the optimal retail price, the optimal wholesale price, the optimal manufacturer’s profit, the optimal retailer’s profit and the total profit are respectively given by

$$
\begin{align*}
  p^* &= \frac{3a + c}{4}, \quad w^* = \frac{a + c}{2}, \quad \pi_M^* = \frac{(a-c)^2}{8}, \\
  \pi_R^* &= \frac{(a-c)^2}{16}, \quad \pi_{Total}^* = \frac{3(a-c)^2}{16}, \quad Q^* = \frac{a - c}{4}.
\end{align*}
$$

It is obvious that there is $\pi_{Total}^* < \pi_{Total}^*$. It means that in a entirely rational setting, the independent channel cannot be coordinated without any necessary cooperation mechanism. The efficiency of the non-coordination channel is only 75% of the cooperation one. How to improve the efficiency of the channel to 100% has been a focus of researches. The quantity discount contract [15] is one of the best contracts compared with other contracts (the two-part tariff, the three-part tariff). We adopt another format of the quantity discount contract which is different from Jeuland and Shugan [15] to improve the channel cooperation.

2.3. Channel coordination of the quantity discount contract (the improvement of the quantity discount contract). The manufacturer offers each unit product to the retailer with the wholesale price $w$. Based on the demand quantity, if the purchasing volume of the retailer is $Q$, the wholesale price given by manufacturer will be $w - \theta Q (0 \leq \theta < \frac{a}{Q})$, where $\theta$ is called the discount coefficient. If $\theta$ is equal to zero, it denotes that the manufacturer does not give any discount to the retailer. The retailer pays a fixed fee $f$ to the manufacturer which does not change with the purchasing volume $Q$. We also adopt backward induction to solve the problem.
The retailer’s profit is given by
\[ \tilde{\pi}_R = (p - w - \theta Q)Q - f = [(1 - \theta)p - w + \theta a](a - p) - f. \] (2)
The first order condition of formula (2) is then given by
\[ \tilde{p}^* = \frac{a + w - 2\theta a}{2(1 - \theta)}. \] (3)
We then have \( \tilde{\pi}_R = \frac{(a-w)^2}{4(1-\theta)} - f \). If the retailer accepts the manufacturer’s quantity discount contract, then the profit should not be less than the profit when the channel is independent which is called individual rationality constraint. Namely
\[ \tilde{\pi}_R^* = \frac{(a-w)^2}{4(1-\theta)} - f \geq \pi^*_R = \frac{(a-c)^2}{16}. \] (4)
It is obvious that the manufacturer tries to maximize the fixed fee \( f \), so we take equal of formula (4) to get
\[ \tilde{\pi}_R^* = \frac{(a-w)^2}{4(1-\theta)} - f = \pi^*_R = \frac{(a-c)^2}{16}. \]
We then have
\[ f = \frac{(a-w)^2}{4(1-\theta)} - \frac{(a-c)^2}{16}. \] (5)
So the manufacturer’s profit is given by
\[ \pi^*_M = \frac{[2(1-\theta)(w-c) - \theta(a-w)](a-w)}{4(1-\theta)^2}. \]
Then the manufacturer would choose the wholesale price \( w \) and the discount coefficient \( \theta \) to maximize the profit. So the problem is given by
\[ \max_{w,\theta} \pi^*_M = \max_{w,\theta} \frac{[2(1-\theta)(w-c) - \theta(a-w)](a-w)}{4(1-\theta)^2}. \] (6)
To achieve the coordination, there should be
\[ \tilde{p}^* = \tilde{p}^{I*} = \frac{a + w - 2\theta a}{2(1-\theta)} = \frac{a+c}{2} \]
and
\[ \theta = \frac{w - c}{a - c}. \] (7)
We further have
\[ \max_w \pi^*_M = \tilde{\pi}_M^* = \frac{3(a-c)^2}{16}. \] (8)
Then the retailer’s profit is given by \( \tilde{\pi}_R^* = \pi^*_R = \frac{(a-c)^2}{16} \) and the manufacturer’s profit is given by \( \tilde{\pi}_M^* = \frac{3(a-c)^2}{16} \). It is clear that \( \tilde{\pi}_M^* + \tilde{\pi}_R^* = \frac{(a-c)^2}{4} = \pi^{I*}_{total} \), so we know that the improved quantity discount contract reaches the efficiency standard of channel coordination. As for the manufacturer, we have \( \tilde{\pi}_M^* = \frac{3(a-c)^2}{16} \geq \frac{(a-c)^2}{8} = \pi^*_M \).
\( \tilde{\omega}^* \) is given by \( \tilde{\omega}^* = a\theta + (1-\theta)c \) from formula (7). Thus, we have the proposition.

**Proposition 1.** In the independent channel, if the profit of retailer with independent decision is not harmed and the manufacturer adopt the quantity discount contract \((\theta, f)\), the channel coordination is achieved. The optimal wholesale price, the optimal retail price and the manufacturer’s and the retailer’s optimal profit are respectively given by
\[ w^* = a\theta + (1-\theta)c, \quad \tilde{f} = \frac{(a-c)^2}{16(1-\theta)}, \quad \tilde{p}^* = \tilde{p}^{I*} = \frac{a+c}{2}, \quad \tilde{\pi}_M^* = \frac{3(a-c)^2}{16}, \quad \tilde{\pi}_R^* = \pi^*_R = \frac{(a-c)^2}{16}, \quad \tilde{\pi}_M^* + \tilde{\pi}_R^* = \frac{(a-c)^2}{4} = \pi^{I*}_{total}. \]

**Commentary 1.** The manufacturer adopts the quantity discount contract \((\theta, f)\) to make the channel reach the efficient level and it restores the retailer’s profit. As for the manufacturer’s profit, it increases by 50% compared with the channel without the quantity discount contract. As for the consumers, the improved contract increases consumers’ welfare, since the retail price \( p^* = \frac{3a+c}{4} \) of channel without
quantity discount contract is reduced to \( \hat{p}^* = p^I = \frac{a + c}{b} \) (the price of integrated channel). The quantity discount contract \((\theta, f)\) has no harm to the retailer’s welfare. However, it generates higher welfare of the manufacturer and the consumers.

3. The fairness preference problem of quantity discount contract (the further improvement of quantity discount contract). In section 3, we assume that the manufacturer and the retailer are both entirely rationality. What they concern about are only their own profits but not the fairness of revenue distribution or behavior motivation. However, in the past years, a series of experiments (like ultimatum game, trust game and gift exchange game) indicate that apart from self-interested preference, people also have fairness preference. They would care about the fairness of profit distribution or behavior motivation when they maximize their own profit. Fairness preference affects the decisions of channel members. For example, people who have fairness preference care about whether the final result of distribution is fair or not. Therefore their utility is a function of their own profit as well as the other’s. In this kind of model, we assume that channel members are confronted with their own profit and the trade-off between the two members. In other words, channel members consider carefully between their own material profit and the fairness of distribution result to maximize their utility. Charness and Rabin [4] proposed a simple linear utility function, including individual fairness preference. We adopt the model of Charness and Robin [4] to build the retailer’s fairness preference utility function. To facilitate the research, we assume that the retailer cares about fairness preference. Let \( \pi_M \) and \( \pi_R \) denote the manufacturer’s and the retailer’s profit, therefore, the retailer’s utility function is given by

\[
U_R = \pi_R - \alpha \max(\eta \pi_M - \pi_R, 0) - \beta \max(\pi_R - \eta \pi_M, 0)
\] (9)

We next analyze the retailer’s utility function. In formula (9), the retailer’s utility function is the sum of his own profit and the distribution fairness level, where \( \max(\eta \pi_M - \pi_R, 0) \) measures the retailer’s disutility of earnings less than those of the manufacturer and \( \max(\pi_R - \eta \pi_M, 0) \) measures the retailer’s disutility of earnings more than those of the manufacturer. \( \alpha \) is different from \( \beta \). The greater the value of \( \alpha \), the more unwilling the retailer are to accept the unequal distribution \((\alpha > 0)\), which is called “Be less, will be jealous”. \((\alpha < 0)\) is equal to a “kind” coefficient, which indicates that it is indifferent to the retailer who gets less profit than the manufacturer. We call it “Be less, will be peace of mind”. The meaning of the coefficient \( \beta \) is analogous. In practice, there is no reason to expect that channel members will split profits equally (e.g. different channel members invest different resources and thus expect profit to be split differently). In the manufacturer-led channel, the manufacturer gets more profit than the retailer under entirely rationality. We give an arbitrary coefficient \( \eta(0 \leq \eta \leq 1) \) to \( \pi_M \) which denotes the level of the retailer emphasis on the manufacturer’s profit. \( \eta = 1 \) captures the highest level and \( \eta = 0 \) captures the lowest level. Of the second term \( \max(\eta \pi_M - \pi_R, 0) \) and the third term \( \max(\pi_R - \eta \pi_M, 0) \) in formula (9), only one can be non-zero. To \( \beta \), previous study (see [10, 2]) suggested that the retailer focused on the amount of negative reciprocity rather than the amount of positive reciprocity. Loch and Wu [18], Cui et al. [7] also suggested that generally speaking, subjects (retailers) exhibit very little positive reciprocity to the more profits of the

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6The retailer’s utility function with the fairness preference come from equation (1) and (2) in [7]. The degree of attention \( \eta \) in this paper is the equitable outcome \( \gamma \) in [7]. The authors are particularly grateful to Cui, Zhang.
manufacturers. Thus, we assume that $\beta = 0$ as in Ho and Zhang\[11\], Katok and Pavlov \[17\]. Then the formula (9) would be reduced to

$$U_R = \pi_R - \alpha(\eta \pi_M - \pi_R, 0)^+.$$  \hfill (10)

For brevity, we introduce sign function $sgn(.)$ into the retailer’s utility function, which is given by $sgn(.) = \begin{cases} 1, & \eta \pi_M - \pi_R \geq 0, \\ 0, & \eta \pi_M - \pi_R < 0. \end{cases}$

Then the formula (10) is equal to

$$U_R = \pi_R - \alpha(\eta \pi_M - \pi_R)sgn(\cdot).$$  \hfill (11)

Charness and Rabin \[4\] presumed that $\alpha$ is within the interval $[-1,1]$. So the following table shows a summary (see in the Table 2):

| Type       | Denomination        | Range of $\alpha$ | Explanation                                                                 |
|------------|---------------------|-------------------|-----------------------------------------------------------------------------|
| I          | Pure self-interest  | $\alpha = 0$      | The model without fairness concerns(common model)                           |
| II         | Competitive preferences | $-1 \leq \alpha < 0$ | The model with the assumption that the retailer gets more profit than the manufacturer does and her utility would be decreased if she gets less |
| III        | Social preferences  | $0 \leq \alpha \leq 1$ | The model with the assumption that the retailer is altruistic and the coefficient of the manufacturer’s profit is positive |

The profit functions of the retailer and the manufacturer are given by

$$\pi_R = (p - w + \theta^F Q)Q - f^F = [(1 - \theta^F)p - w + \theta^F a](a - p) - f^F,$$

$$\pi_M = (w - \theta^F Q - c)Q + f^F = (w - \theta^F a)p - c + \theta^F p](a - p) + f^F.$$

We substitute $\pi_R, \pi_M$ into formula (11).

$$\pi_R = [(1 - \theta^F)p - w + a\theta^F] - f^F + \alpha(\eta + 1)f^F sgn(\cdot)$$

$$- \alpha[\eta(w - a\theta^F - c + p\theta^F) - (p - p\theta^F - w + a\theta)](a - p)sgn(\cdot).$$  \hfill (12)

The first-order conditions of formula (12) are as follows.

$$(1 - 2\theta^F)a - 2(1 - \theta^F)p^{F*} + w - \alpha[\eta \theta^F - 1 + \theta^F](a - p^{F*}) - \eta(w - \theta^F a - c + \theta^F p^{F*})$$

$$+ p^{F*} - \theta^F - w + \theta^F a)sgn(\cdot) = 0.$$

If we let

$$U = \frac{(1 - 2\theta^F)a - \alpha \eta \theta^F - a + 2\theta^F a + \eta c)}{2(1 - \theta^F) - \alpha \eta \theta^F - 2(1 - \theta^F)}$$

and

$$V = \frac{1 + \alpha \eta \theta^F + \eta \theta^F}{2(1 - \theta^F) - \alpha \eta \theta^F - 2(1 - \theta^F)}.$$

Then the first-order conditions of formula (12) is rewritten in the form

$$p^{F*} = U + Vw.$$
Therefore, we have
\[
U_R = \left[(1 - \theta^F)(U + Vw) - w + a\theta^F\right](a - U - Vw) - f^F \\
- \alpha \text{sgn}(\cdot)\{\eta(w - \theta^F a - c + \theta^F U + \theta^F Vw) \\
- (U + wV - \theta^F U - \theta^F Vw - w + \theta^F a)\}(a - U - Vw) + (\eta + 1) f^F \}.
\]

If the retailer accepts the quantity discount contract which is based on fairness preference, then her profit should be no less than the profit she gets from the independent channel. Therefore, we have
\[
U_R = \left[(1 - \theta^F)(U + Vw) - w + a\theta^F\right](a - U - Vw) - f^F - \alpha \text{sgn}(\cdot)\{\eta(w - \theta^F a - c + \theta^F U + \theta^F Vw) \\
- (U + wV - \theta^F U - \theta^F Vw - w + \theta^F a)\}(a - U - Vw) \geq \pi_R^* \\
= \frac{(a - c)^2}{16}.
\]

The manufacturer hopes the larger \( f^F \). Therefore, the formula (13) becomes equality, and thus we have
\[
f^F = \frac{(a - U - Vw)}{\left[1 - \alpha \text{sgn}(\cdot)(1 + \eta)\right]}\left[(1 - \theta^F)(U + Vw) - w + a\theta^F - \eta \text{sgn}(\cdot)\{w - \theta^F a - c + \theta^F U + \theta^F Vw\} \\
- (U + wV - \theta^F U - \theta^F Vw - w + \theta^F a)\}(a - U - Vw) \right] - \frac{(a - c)^2}{16[1 - \alpha \text{sgn}(\cdot)(1 + \eta)]}.
\]

Note that \( \pi_M = (w - \theta^F Q - c)(a - p) + f^F \), we get
\[
\pi_M^F = \frac{(a - U - Vw)}{\left[1 - \alpha \text{sgn}(\cdot)(1 + \eta)\right]}\left[(1 - \theta^F)(U + Vw) - w + a\theta^F - \eta \text{sgn}(\cdot)\{w - \theta^F a - c + \theta^F U + \theta^F Vw\} \\
- (U + wV - \theta^F U - \theta^F Vw - w + \theta^F a)\}(a - U - Vw) \right] - \frac{(a - c)^2}{16[1 - \alpha \text{sgn}(\cdot)(1 + \eta)]}.
\]

The manufacturer chooses \( w \) and \( \theta \) to maximize her profit by solving the following problem
\[
\max_{w, \theta} \pi_M^F = \max_{w, \theta} \frac{(a - U - Vw)}{\left[1 - \alpha \text{sgn}(\cdot)(1 + \eta)\right]}\left[(1 - \theta^F)(U + Vw) - w + a\theta^F - \eta \text{sgn}(\cdot)\{w - \theta^F a - c + \theta^F U + \theta^F Vw\} \\
- (U + wV - \theta^F U - \theta^F Vw - w + \theta^F a)\}(a - U - Vw) \right] - \frac{(a - c)^2}{16[1 - \alpha \text{sgn}(\cdot)(1 + \eta)]}.
\]
To be coordinated, we have \( p^{F*} = p^{I*} \). Thus, \( w^{F*} \) is given by
\[
\frac{(a+c)\{(1-\theta F) - [\eta \theta F - (1-\theta F)]\text{sgn}(.)\} - (1-2\theta F)a}{1 + \text{sgn}(.) + \eta \text{sgn}(.) + \alpha \text{sgn}(.) + \eta \alpha \text{sgn}(.)} + \frac{\text{sgn}(.) (2\eta \alpha \theta F + 2\alpha F) - a + \eta c}{1 + \alpha \text{sgn}(.) + \eta \alpha \text{sgn}(.)}.
\]
Note that \( Q^{F*} = a - U - V w = \frac{2-a}{2} \), we have
\[
\pi^{F*}_M = \frac{(a-c)^2}{16} \frac{[4\text{sgn}(.) - 8\theta F \text{sgn}(.) (\eta + 1) + 3]}{[1 - \text{sgn}(.) (\eta + 1)]}.
\]
The retailer’s profit is given by \( U^{F*}_R = \bar{\pi}^* = \pi^*_R = \frac{(a-c)^2}{16} \), which is the same as the profit without fairness concerns. The total profit (utility) of channel is given by
\[
\pi^{F*}_{\text{Total}} = \pi^{F*}_M + U^{F*}_R = \frac{(a-c)^2}{4} + \frac{(a-c)^2 [4 \text{sgn}(.) + (3-8\theta F) \text{sgn}(.) (\eta + 1)]}{16[1 - \text{sgn}(.) (\eta + 1)]}.
\] (14)

Therefore, we get the conclusion.

**Proposition 2.** If the channel is independent and the retailer is fair-minded, the manufacturer chooses the quantity discount contract \((\theta^F, f^F)\). The optimal wholesale price, the retail price, the manufacturer’s profit, the retailer’s profit, the total profit are as follows
\[
w^{F*} = \frac{(a+c)\{(1-\theta F) - [\eta \theta F - (1-\theta F)]\text{sgn}(.)\} - (1-2\theta F)a}{1 + \text{sgn}(.) + \eta \text{sgn}(.) + \alpha \text{sgn}(.) + \eta \alpha \text{sgn}(.)} + \frac{\text{sgn}(.) (2\eta \alpha \theta F + 2\alpha F) - a + \eta c}{1 + \alpha \text{sgn}(.) + \eta \alpha \text{sgn}(.)},
\]
\[
p^{F*} = \frac{(a+c)}{2},
\]
\[
\pi^{F*}_M = \frac{(a-c)^2}{16} \frac{[4\text{sgn}(.) - 8\theta F \text{sgn}(.) (\eta + 1) + 3]}{[1 - \text{sgn}(.) (\eta + 1)]},
\]
\[
U^{F*}_R = \bar{\pi}^* = \pi^*_R = \frac{(a-c)^2}{16},
\]
\[
\pi^{F*}_{\text{Total}} = \pi^{F*}_M + U^{F*}_R = \frac{(a-c)^2}{4} + \frac{(a-c)^2 [4 \text{sgn}(.) + (3-8\theta F) \text{sgn}(.) (\eta + 1)]}{16[1 - \text{sgn}(.) (\eta + 1)]}.
\]

**Commentary 2.** If the retailer is fair-minded, the manufacturer chooses the quantity discount contract \((\theta^F, f^F)\), which increases customers’ welfare.

Because the retail price of channel without quantity discount contract \( p^* = \frac{3a+c}{4} \) reduces to \( p^{F*} = \frac{a+c}{2} \) (the price of integrated channel), the quantity discount contract \((\theta^F, f^F)\) has no effect on the retailer’s welfare. However, it generates higher welfare of the manufacturer and customers.
4. Can channels achieve coordination by the quantity discount mechanism with the fairness preference? We know that the channel integrated profit is $\pi_{\text{total}}^* = \frac{(a-c)^2}{4}$. We hope that the channel profit under the introduction of fairness preferences is not less than that under the channel integration $\pi_{\text{total}}^* \geq \pi_{\text{total}}^*$. To make it simple, in the (14), we write

$$g(\alpha, \eta, \theta) = \frac{(a-c)^2[4\alpha \text{sgn}(\eta) + (3 - 8\theta^F)\text{sgn}(\eta)(\eta + 1)]}{16[1 - \alpha \text{sgn}(\eta)(\eta + 1)]}. \quad (15)$$

As long as $g(\alpha, \eta, \theta) = 0$, channels coordination is achieved.

Note that $\text{sgn} = \begin{cases} 1, & \eta \pi_M^* - \pi_R^* \geq 0 \\ 0, & \eta \pi_M^* - \pi_R^* < 0 \end{cases}$, the formula (15) is rewritten as

$$g(\alpha, \eta, \theta) = \begin{cases} \frac{(a-c)^2[4\alpha - 8\theta^F\alpha(\eta + 1) + 3\alpha(\eta + 1)]}{16[1 - \alpha(\eta + 1)]}, & \eta \pi_M^* - \pi_R^* \geq 0 \\ 0, & \eta \pi_M^* - \pi_R^* < 0 \end{cases}. \quad (16)$$

Then $f^F$ in the proposition 2 is rewritten as

$$f^F = \begin{cases} \frac{(a-c)^2[1 - \theta^F](4\alpha - 4\eta\theta^F - 1)}{16[1 - \alpha(\eta + 1)]}, & \eta \pi_M^* - \pi_R^* \geq 0 \\ \frac{(a-c)^2(4\alpha - 4\theta^F)}{16}, & \eta \pi_M^* - \pi_R^* < 0, \end{cases} \quad (17)$$

For any $\eta, (0 \leq \eta \leq 1)$, if $\eta \pi_M^* - \pi_R^* < 0$, under the given quantity discount mechanism $(\theta^F, f^F)$, we find that channel efficiency can reach the level of channel coordination, namely, $\pi_{\text{total}}^* = \frac{(a-c)^2}{4} = \pi_{\text{total}}^*$. Because of $\pi_R^* = \frac{(1-\theta)(a-c)^2}{4} - f^F, \pi_M^* = \frac{\theta(a-c)^2}{4} + f^F$, substituting them into $\eta \pi_M^* - \pi_R^* < 0$, we get $0 \leq \eta < \frac{1}{3}$. From this result, if the retailer has a fairness preference, when $\eta$ meets $0 \leq \eta < \frac{1}{3}$, channel can achieve cooperation under given quantity discount mechanism $(\theta^F, f^F)$.

Next, we discuss the expression (16). Namely, under the conditions $\eta \pi_M^* - \pi_R^* \geq 0$, can channel achieve cooperation? Substituting $\pi_R^* = \frac{(1-\theta)(a-c)^2}{4} - f^F, \pi_M^* = \frac{\theta(a-c)^2}{4} + f^F$, and $f^F$ (the first expression of equation (17)) into $\eta \pi_M^* - \pi_R^* \geq 0$, we have

$$4[1 - \alpha(\eta + 1)][(\eta \theta - 1 + \theta) + (\eta + 1)][(1 - \theta^F)(4 + 4\alpha) - 4\eta\theta^F - 1] \geq 0. \quad (18)$$

If the channel is coordinated, then we have

$$g(\alpha, \eta, \theta) = \frac{(a-c)^2[4\alpha - 8\theta^F\alpha(\eta + 1) + 3\alpha(\eta + 1)]}{16[1 - (\eta + 1)]} = 0. \quad (19)$$

From equation (19), $\theta^F$ can be given as $\theta^F = \frac{1 + 3\eta(\eta + 1)}{8(\eta + 1)}$. Substituting the (18) formula, we have

$$3\alpha\eta^2 - (3 - 2\alpha)\eta + 1 - \alpha \leq 0. \quad (20)$$

(1) When $\alpha = 0$, solving inequality (20), we have $\eta \geq \frac{1}{3}$.

(2) When $\alpha \neq 0$, solving inequality (20), if $\alpha \geq \frac{3}{4}$, we have $\frac{1-\alpha}{\alpha} \leq \eta \leq \frac{1}{3}$. If $\alpha < \frac{3}{4}$, we have $\frac{1}{3} \leq \eta \leq \frac{1-\alpha}{\alpha}$. Note that $-1 \leq \alpha \leq 1$ and $0 \leq \eta \leq 1$, we get

(i) $\frac{3}{4} \leq \alpha \leq 1, \frac{1-\alpha}{\alpha} \leq \eta \leq \frac{1}{3}$;  
(ii) $\frac{1}{2} \leq \alpha \leq \frac{3}{4}, \frac{1}{3} \leq \eta \leq \frac{1-\alpha}{\alpha}$.

We furthermore have

(i) $\frac{3}{4} \leq \alpha \leq 1, 0 \leq \eta \leq \frac{1}{3}$;  
(ii) $\frac{1}{2} \leq \alpha \leq \frac{3}{4}, \frac{1}{3} \leq \eta \leq 1$. 

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From formula (17), we obtain

$$F^* = \begin{cases}
\frac{(a-c)^2(3\alpha - 3\alpha_1)}{32(1-\alpha_1)}, & \frac{3}{4} \leq \alpha \leq 1, 0 \leq \eta \leq \frac{1}{3}, \\
\frac{(a-c)^2(3\alpha - 3\alpha_2)}{32(1-\alpha_2)}, & \frac{3}{4} \leq \alpha \leq \frac{3}{4}, \frac{1}{3} \leq \eta \leq 1, \\
\frac{3(a-c)^2}{32(\alpha_1 + 1)}, & \alpha = 0, \frac{1}{3} \leq \eta \leq 1, \\
\frac{3(a-c)^2(3\eta-1)}{32(\eta+1)}, & -1 \leq \alpha \leq \frac{3}{4}, 0 \leq \eta \leq \frac{1}{3}.
\end{cases}$$

In summary, for the given $\theta^F = \frac{4 + 3(\eta + 1)}{8(\eta + 1)}$, and the above $F^*$, the channel can be coordinated if either of the following conditions is met

- **condition 1**: $\frac{3}{4} \leq \alpha \leq 1$, $0 \leq \eta \leq \frac{1}{3}$,
- **condition 2**: $\frac{3}{4} \leq \alpha \leq \frac{3}{4}$, $\frac{1}{3} \leq \eta \leq 1$,
- **condition 3**: $\alpha = 0$, $\frac{1}{3} \leq \eta \leq 1$,
- **condition 4**: $-1 \leq \alpha \leq \frac{3}{4}$, $0 \leq \eta \leq \frac{1}{3}$.

From the above, we get the following proposition.

**Proposition 3.** In the independent hierarchical channels, on the premise of not harming the retailers’ profits, if the quantity discount mechanism $(\theta^F, F^*)$ which are adopted by manufacturers, the coefficient $\alpha$ of the retailer’s fairness preferences and the degree $\eta$ of attention on the manufacturer’s profit meet one of the following conditions, channel coordination is achieved, profit is also equal to the profit of channel integration;

- **condition 1**: $\frac{3}{4} \leq \alpha \leq 1$, $0 \leq \eta \leq \frac{1}{3}$;
- **condition 2**: $\frac{3}{4} \leq \alpha \leq \frac{3}{4}$, $\frac{1}{3} \leq \eta \leq 1$;
- **condition 3**: $\alpha = 0$, $\frac{1}{3} \leq \eta \leq 1$;
- **condition 4**: $-1 \leq \alpha \leq \frac{3}{4}$, $0 \leq \eta \leq \frac{1}{3}$.

Below are some notes about the coordination conditions in the proposition 3.

**A** Apparently conditions 1 and 2 can be combined into one. In fact the different value ranges of $\alpha$ corresponding to that of $\eta$.

**B** Condition 3: $\alpha = 0$, $\frac{1}{3} \leq \eta \leq 1$, the coefficient of the retailer’s fairness preferences $\alpha = 0$. It means “self-interest” in the narrow sense, i.e. the channel quantity discount mechanism does not consider the fairness preferences. Actually it is the second case(proposition 2). Proposition 2 can be seen as a special case of proposition 3. Apparently the fixed costs $f = \frac{(a-c)^2(3-4\eta)}{16}$ in proposition 2 is different to $f^* = \frac{(a-c)^2(3\eta - 1)}{32(\eta + 1)}$ in proposition 3. But in fact they are the same because in order to achieve the coordination after introducing the fairness preferences, we need to set the quantity discount coefficient $\theta^F = \frac{4 + 3(\eta + 1)}{8(\eta + 1)}$. From the equation we can solve $\eta$. Substituting $\eta$ into $f^*$, we get $f^* = \frac{(a-c)^2(3-4\eta)}{16}$. Meanwhile the proposition 3 shows that adopting the advanced quantity discount mechanism can achieve the channel coordination. Combined with proposition 2, the wholesale price is $w^* = (a-c)\theta^F + c$. It can explain that adopting the simple wholesale price and the quantity discount coefficient $\theta^F = \frac{4 + 3(\eta + 1)}{8(\eta + 1)}$ by manufacturers can achieve the channel coordination. Compared with the other complex coordination mechanism, it has some obvious advantages (simple and easy to implement). Just like Holmstrom and Milgrom’s [12] opinion, in the reality world, a simple contract is often the optimal.

**C** Explanation about condition 1: $\frac{3}{4} \leq \alpha \leq 1$, $0 \leq \eta \leq \frac{1}{3}$. When $0 \leq \alpha \leq 1$, it belongs to the social welfare preferences. In that case, the retailers have the altruistic tendency, the retailer is not too concerned about the profits of the manufacturer (because the emphasis coefficient $\eta$ is smaller, $0 \leq \eta \leq \frac{1}{3}$). In this case
it is easy to achieve coordination. Looking at the fixed costs \( f^F = \frac{(a-c)^2(3+\alpha-3\alpha\eta)}{32(1-\alpha(\eta+1))} \), because of \( \frac{\partial f^F}{\partial \eta} = \frac{(a-c)^2\alpha^2}{8(1-\alpha(\eta+1))} \geq 0 \), i.e. the emphasis coefficient \( \eta \) is smaller, the fixed costs \( \eta \) is less.

(D) Condition 2 shows that we are able to achieve the coordination when the retailer has the fairness preferences in the improved quantity discount mechanism.

According to proposition 3, it must meet the certain conditions to achieve the channel coordination. In line with the proof of proposition 3, we can get proposition 4 by modifying the proposition 2 as follows.

**Proposition 4 (The amendment of proposition 2).** In the independent hierarchical channels, when the retailer has the fairness preferences and the manufacturer adopts the quantity discount mechanism \((q^F, f^F)\), the optimal wholesale price, the optimal retail price, the manufacturer’s optimal profit, the retailer’s optimal profit and the total profit in channel are

\[
\begin{align*}
\hat{w}^F &= \frac{(5c + 3a)\eta + 7(a + c)}{8(\eta + 1)}, \\
\hat{p}^F &= p^F = \frac{a + c}{2}, \\
\hat{\pi}^F &= \frac{3(a - c)^2}{16}, \\
\hat{U}^F_R &= \hat{\pi}_R = \pi_R = \frac{(a - c)^2}{16}, \\
\hat{\pi}^F_{Total} &= \frac{4 + 3(\eta + 1)}{8(\eta + 1)}, \\
\hat{\theta}^F &= \frac{4 + 3(\eta + 1)}{8(\eta + 1)}, \\
\hat{f}^F &= \begin{cases} 
\frac{(a-c)^2(3+\alpha-3\alpha\eta)}{32(1-\alpha(\eta+1))}, & 3 \leq \alpha \leq 1, 0 \leq \eta \leq \frac{1}{3}, \\
\frac{(a-c)^2(3+\alpha-3\alpha\eta)}{32(1-\alpha(\eta+1))}, & \frac{1}{3} \leq \alpha \leq \frac{3}{4}, \frac{1}{3} \leq \eta \leq 1, \\
\frac{3(a-c)^2}{32}, & \alpha = 0, \frac{1}{3} \leq \eta \leq 1, \\
\frac{(a-c)^2(3\eta-1)}{32(\eta+1)}, & -1 \leq \alpha \leq \frac{3}{4}, 0 \leq \eta \leq \frac{1}{3}.
\end{cases}
\end{align*}
\]

From Proposition 4 and [7], both of them can reach the level of the channel coordination (the same optimal retail price, the same channel profit), but the wholesale price implemented by the manufacturer and the distribution of the channel profit is different. See Table 3:

| Decision variable or profit | Cui et al. [7] | The quantity discount mechanism based on fairness preferences |
|-----------------------------|----------------|-----------------------------------------------------------|
| Wholesale price             | \( w^{C^*} = \frac{4(a+c)+8pc}{2(1+\eta)} \) | \( w^{F^*} = \frac{7(a+c)+15pc}{8(1+\eta)} \) |
| Retail price                | \( p^{C^*} = \frac{a+c}{2} \) | \( p^{F^*} = \frac{a+c}{2} \) |
| Fixed cost                  | \( f^{C^*} \) | \( f^{F^*} \) |
| the retailer’s profit       | \( \pi^{C^*_R} = \frac{(a-c)^2\eta}{4(1+\eta)} \) | \( \pi^{F^*_R} = \frac{(a-c)^2}{16} \) |
| the manufacturer’s profit   | \( \pi^{C^*_M} = \frac{(a-c)^2}{4(1+\eta)} \) | \( \pi^{F^*_M} = \frac{(a-c)^2}{16} \) |
| the total profit in channel | \( \pi^{C^*_Total} = \frac{(a-c)^2}{4} \) | \( \pi^{F^*_Total} = \frac{(a-c)^2}{4} \) |

**Commentary 3.** Table 2 provides a comparison of the findings in this paper.

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7 This paper assumes that \( q = a - p \), which means \( b = 1, \gamma \) in Cui et al[2007] is \( \eta \) in this paper.
The reasons that they arrive at different results are the following: First, Cui et al. [7] apply the fairness preference theory to achieve channel coordination, we apply the fairness preference theory to a quantity discount mechanism. Second, Cui et al. [7] shows that retailer’s profits of the channel coordination profit distribution may infinite tends to zero, this paper are that retailer’s profits are equal to the profits of independent decision-making, this is the basic condition which retailers are willing to coordination, otherwise, retailers would rather independent decision. This is consistent with the reality. Therefore, our model can be viewed as an extension to Cui et al. [7].

We can get proposition 5 from Table 2.

**Proposition 5.** In the independent hierarchical channels, if profits of retailer who has fairness preferences is not less than the profits of independent decision-making, (without coordination mechanism), and the manufacturer adopts the quantity discount mechanism($\theta^F, f^F$), the optimal wholesale price and the retailer’s optimal profit are independent of $\alpha$, $\eta$, $\theta^F$ ($\alpha$ is the coefficient of the retailer’s fairness preferences, $\eta$ is the degree of attention on the manufacturer’s profit, $\theta^F$ is the manufacturer’s discount factor of the retailer’s wholesale price ).

In order to achieve the coordination, we execute the retail price which is equal to the retail price of the channel integration, and the retailer’s profit is less than the profit of independent decision-making, which is different from other mechanisms. For instance, the manufacturers charge with fixed costs to make the retailers’ profits be zero in the quantity discount mechanism of Jeuland, Shugan [15]. However it is not in accordance with the reality.

5. Conclusion. How to achieve the channel coordination has always been a hot topic. This paper improves the idea of the research presented in Cui et al. [7]. First of all, we study the general problem of channel decisions( the channel integration and the independent hierarchical channel). Secondly, we improve the quantity discounts mechanism which is different from that presented in Jeuland and Shugan [15]. The manufacturer sells to the retailer at the biggest wholesale price per unit of product, and cuts the wholesale price in accordance with the size of the demand. Through this mechanism, we achieve the channel coordination. Thirdly, all researches are based on the complete rational assumption. However, in reality, a great deal of games (ultimatum game, gift exchange game, et al.) indicate that decision-makers show a bounded rationality, a form of which is fairness preferences. In this paper, mechanism with quantity discounts based on a fairness preference theory is embedded in channel research of coordination and game model of the channel discount mechanism is constructed based on fairness preference. The results show that as long as the degree of attention (parameters) with retailers to manufacturer’s profit and fairness preference coefficients (parameters) of retailers satisfy certain conditions, by performing a simple wholesale price and fixed costs, channels of coordination can be achieved. Compared with the study in [7], both research ideas can achieve channel coordination. But it is not the same as the allocation of profits. Cui et al. [7] think that allocation ratio of the profit with channels coordination is associated with the parameters. However, under the premise, our study ensures that retailer profits are equal to the profits of independent decision-making channels when coordination is achieved.
However, some problems are still left for further study.

(1) This study is mainly based on a simple channel structure (between a manufacturer and a retailer). Can coordination be achieved in the channels in which consist of a number of manufacturers and one retailer while the fair preference theory is linked with the channel structure?

(2) When a fair preference theory is embedded in channel, can coordination be achieved in the channels which have a number of retailers and only one manufacturers?

(3) The quantity discount mechanism can be described as this status which retailer pays part of the fixed costs (the retailer’s loss) to the manufacturers, and then gets profit from the channels (retailers’ gain). However, with the sale increasing, the more the manufacturer discounts, the faster profits increases. With the losses and gains, how does the retailer look at it? Kahneman et al. [16] think if the retailer is loss aversion, the retailers will pay more attention to the previous losses than the later profits. Is the quantity of discount mechanism ($\theta, f$) effective to loss aversion retailers? Is coordination achieved in the channels? These problems will continue to be explored.

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