COORDINATION WITH SUPPLY CHAIN CONTRACTS IN THE PRESENCE OF TWO DIFFERENT CONSUMER SEGMENTS

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Abstract
This paper models a supply chain of a manufacturer, a retailer and two different consumer segments. One segment has a high willingness-to-pay and the other a low willingness-to-pay. The manufacturer decides on the wholesale price and the selling price is determined by the retailer. It is well known that a straightforward wholesale price contract does not coordinate the channel. In this paper we show that two other types of contracts, namely the revenue sharing and the profit sharing mechanisms do coordinate the supply chain and, furthermore, provide win-win for the entire range of parameter values. Our analysis has also established an equivalence relationship between the revenue and the profit sharing mechanisms. It is also shown that the pull discount mechanism (that is: the manufacturer provides a discount directly to the end consumers) coordinates for a greater range of parameter values compared to the wholesale price discount but not for the entire possible range.

Moreover, for the situation where the manufacturer designs the targeted push-pull discount (Manufacturer provides a wholesale price discount to the retailer and a pull discounts which can be availed only by the low willingness to pay consumers) it is shown that it is possible for the channel to make a greater profit by extracting surplus from the high willingness-to-pay customers. However, “targeted push-pull” is feasible only with certain restrictions. Interestingly, we found that the revenue sharing or the profit sharing mechanisms with the targeted pull discount is feasible when the “targeted push-pull” fails to coordinate. Even, in this case the performance of the targeted pull discount in combination with the revenue or profit sharing mechanisms is equivalent.

Key words
Pull discounts, Push discounts, Contract mechanisms, Channel coordination & win-win.

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1. Introduction

Price differentiation between different customer segments is a very well known practice in industries such as the airlines, hotels, car rentals etc. Different price/service combinations are used to create barriers between different customer segments. This issue has been addressed in the revenue management literature in a great detail. More recently the revenue management principles are also used by the product based companies such as Dell. Dell’s success with differentiated and dynamic pricing practice can be attributed to its unique supply chain design and also because it uses internet as its predominant selling channel. However, it might not always be feasible to price differentiate and create barriers between different consumer segments. Consider a case of a consumer electronics retailer selling camcorders in a retail store. It is very likely that the customers with different willingness-to-pay would arrive at the same retail store. It is possible to classify these consumers into different segments based on their willingness-to-pay. For instance if we could classify the consumers into two different segments where the one segment has a low willingness-to-pay and the other segment having a high willingness to pay. In a situation like this the retailer would try to maximize his profit by selling only to the high segment customers even though selling to both the segments might be a more profitable option for the entire channel. The present paper designs mechanisms which can coordinate such a channel. In this case the manufacturer and retailer’s self-interested marketing decisions is the cause for channel inefficiency which is commonly addressed and understood as double marginalization in the literature (see e.g. Spengler (1950), Moorthy (1988), Bolton and Bananno (1988), Tirole (1989, pp. 174-175), Lilien, Kotler, and Moorthy (1992, p.419)).

Double marginalization is said to be eliminated and the channel coordinated when the channel is able to achieve the profit as in a centralized scenario. Any solution focused in the above direction will be acceptable to both players only when it provides some additional benefit to each of the player. This is generally referred to as win-win. Supply chain management literature addresses the above issue by modification of the terms of trade through contracts over certain trade parameters(variables). This approach aims to achieve coordination between business entities by providing incentives to share risks and/or rewards. In this paper we design revenue and profit sharing mechanism to test
coordination and win-win in a setting in which different consumer segments cannot be addressed by the revenue management principles.

This particular problem has been addressed in the past by Gerstner and Hess (1995, 1991). They design a pull pricing mechanism (manufacturer offers discounts directly to consumer) and show that the pull discount mechanism coordinate for a certain range of parameter values. They also design targeted push-pull discount (pull discount is accessible only to the price sensitive customers and a wholesale price discount is provided to the retailer). Their analysis shows that the channel is better off as it is able to extract greater surplus from the end consumers. Unfortunately, even this mechanism fails to coordinate for a certain range of parameter values. In this paper we also show that the targeted pull discount mechanism in combination with the revenue or the profit sharing mechanism is able to coordinate the channel for the parameter values in which the targeted push-pull mechanism fails to do so.

In the next section the model and the numerical example that will be used to understand the relevance of the obtained results will be introduced. It also discusses the decentralized and centralized scenario analysis. In Section 3 we design the revenue sharing and the profit sharing mechanism and test their ability to coordinate and provide win-win. We also discuss the pull discount mechanism. In section 4 the targeted push-pull discounts and targeted pull discount in combination with the revenue and the profit sharing mechanism are designed. In section 5 we provide the final conclusions.

2. Model

As shown in the figure 1 a monopolist manufacturer distributes a single product through an exclusive independent retailer. The retailer sets the price to maximize retail profit, and the manufacturer decides on the wholesale price. Manufacturing and retailing costs are
assumed for simplicity to be zero. We follow the standard principle/agent tie-breaking assumption that when the retailer earns equal profits in two different alternatives, he chooses the alternative preferred by the manufacturer. It is also assumed that both the manufacturer and the retailer has symmetric and complete information.

Two consumer segments make up the market: high willingness-to-pay consumers (Highs for short) and low willingness-to-pay consumers (Lows for short). The product is sold to the retailer at a wholesale price $W$, and the retailer resells that product at a retail price $P$. The Highs place a reservation price, $P_H$, on the product, and the Lows have a reservation price $P_L$, where $0 < P_L < P_H$. It is convenient to normalize the size of the market to 1.0 ($Q$ is normalized to 1). Let $\alpha$ be the segment size of Highs and $1- \alpha$ be the segment size of Lows. For the rest of our analysis we assume that $P_L > \alpha P_H$ (With this assumption we make sure that it is profitable to sell to both the segments than to sell it to only to the highs).

When $P_L > \alpha P_H$ holds, a vertically integrated firm would have fixed the price in such a way that it would be able to sell its product to the entire market (i.e. at $P_L$). The profit for the channel when it sells to the entire market is $P_L$. However, in a decentralized channel, the retailer always considers seeking a large margin by selling only to the highs at their reservation price, $P_H$. The manufacturer’s best response to a retailer who pursues large margins is to set the wholesale price equal to $P_H$, driving the retailer’s profit to zero. So the manufacturers channel profit is $\alpha P_H$, which incidentally is the same for the entire channel. This phenomena in which each player tries to maximize his/her own profit leading to a non optimal supply chain profit is famously called as double marginalization.

The double marginalization can be eliminated if the manufacturer sets his wholesale price such that it would encourage the retailer to fix the retail price at $P_L$, thus making a sale to both the segments. Let $W$ be the wholesale price fixed by the manufacturer in this scenario. The retailers profit from selling only to highs at a price $P_H$ is $\alpha(P_H - W)$. The profit from selling to all customers at a price $P_L$ is $(P_L - W)$. To obtain channel coordination, the manufacturer adjusts the wholesale price until the retailer is just indifferent between the two options. Setting the two retail profit expressions equal yields the following wholesale price:
The resulting profits for the manufacturer and the retailer when both Highs and Lows buy are,

\[ W_i = P_H - \frac{(P_H - P_L)}{(1 - \alpha)} \]  

(1)

The total channel’s profit is \( P_L \). The independent manufacturer prefers to sell only to highs and to exclude the lows if profit \( \pi^{m}_i \) is less than the profit from selling only to highs, \( \alpha P_H \); this occurs when,

\[ P_L < \alpha P_H (2 - \alpha). \]  

(4)

Double marginalization occurs when

\[ \alpha P_H < P_L < \alpha P_H (2 - \alpha) \]  

(5)

To better understand the significance of the above result, \( P_L \) is represented along a one dimensional axis and the behavior of the supply chain for different values of \( P_L \) is very well depicted in figure 2. When \( P_L < \alpha P_H \), even a centralized channel would sell only to the high end consumers. From 4 it is clear that when \( P_L > \alpha P_H (2 - \alpha) \) the manufacturer is interested in providing the wholesale price that the retailer would be interested in and the channel would coordinate. Only when \( P_L \) satisfies the condition in 5 i.e. when \( \alpha P_H < P_L < \alpha P_H (2 - \alpha) \) (indicated as a dotted line in figure 2) the channel does not coordinate and the double marginalization occurs.
The above generalization can easily be followed from the following example. The willingness to pay for highs and lows is considered to be $3.00 and $2.00 respectively. Half the market consists of highs and half lows. With these parameter values the double marginalization phenomena can be easily observed as $1.5 < P_L < 2.25$.

For this example the retailer would sell to both the segments when the wholesale price is less than or equal to $1.00. However at any wholesale price that the manufacturer fixes in this range he gets a lower profit than what he gets when he fixes the wholesale price at $2.00. When the manufacturer does this the retailer would sell only to the highs and the total channel profit would be $1.50 which is lower than the centralized channel profit i.e. $2.00. These results are depicted in figure 3. In the next section we design mechanisms which coordinate the above supply chain.
3. Coordination mechanisms

This section introduces various coordination mechanisms namely the revenue sharing, profit sharing and the pull discount mechanism. The objective is to test if these mechanisms can coordinate the channel (maximum channel profit is obtained) and provide win-win (both the players make a greater profit than when they are operating independently). Supply chain (SC) contracts are coordination mechanisms that utilize incentives to make SC players’ decisions coherent among each other. In particular, the incentives let the risk and the revenue (which arise from different sources of uncertainty and from channel coordination, respectively) be shared by all players.

Different models of SC contracts have been developed in the literature. They include the quantity flexibility contracts Tsay, (1999), the backup agreements Eppen and Iyer, (1997),
the buy back or return policies (Pasternack, (1985), Emmons and Gilbert, (1998), Padmanabhan and Png, (1997)), the incentive mechanisms Lee and Whang, (1999), the revenue sharing contracts (Cachon and Lariviere, (2005), Dana and Speir, (2001)) and the Quantity discounts Weng, (1995). Contract Mechanisms have also been studied extensively in the economics and marketing science literature where the issue of designing contractual agreements arises when a supplier uses intermediate firms to reach final consumers. Tirole, (1988) and Katz, (1989) provide excellent reviews of contracts in economics literature. Cachon (2003) has discussed the supply chain coordination with the contract mechanisms. In this paper we analyze the revenue and the profit sharing mechanisms in detail as they are able to provide coordination and win-win. In the next subsection we test the effectiveness of the revenue sharing mechanism.

3.1. Revenue sharing mechanisms

In the revenue sharing mechanism the transactions between the supplier and buyer are governed by the supplier receiving a share of the buyer’s revenues. The revenue sharing mechanism can be identified by two parameters, namely, wholesale price $W$ and a percentage of the buyers profit $\gamma$ ($0<\gamma<1$), that goes to the supplier. Many supply contracts in vertically-separated industries include revenue sharing. One recent example is from video-cassette rental industry, see (Cachon & Lariviere, (2005), Dana & Speir, (2001)). With the revenue sharing mechanisms the retailers profit when he sells only to the highs is,

$$\alpha(P_H - W_2) - \gamma \alpha P_H$$

(6)

and the retailers profit when he sells to the entire market is:

$$P_L - W_2 - \gamma P_L$$

(7)

The wholesale price should be set such that the retailer is indifferent between the above two options. That will happen when the manufacturer selects the wholesale price such that retailer’s profit in equations 6 and equation 7 are equal:

$$\alpha(P_H - W_2) - \gamma \alpha P_H = P_L - W_2 - \gamma P_L$$

(8)

$$W_2 = (1-\gamma)[P_H - \frac{(P_H - P_L)}{(1-\alpha)}]$$

(9)
The wholesale price is dependent on the percentage of the revenues shared and the wholesale price is a decreasing function of the percentage of revenues shared. The wholesale price is lower than the wholesale price at which the retailer would cooperate in a decentralized channel (Equation 1). The manufacturer would be interested in supplying the product at this wholesale price as he will be receiving a share of retailer’s revenue in addition to the wholesale price.

The profit for the manufacturer with the revenue sharing mechanism can be obtained as

\[ \pi_2^m = W_2 + \gamma P_L \]  

(10)

\[ \pi_2^m = (1 - \gamma)[P_H - \frac{(P_H - P_L)}{(1 - \alpha)}] + \gamma P_L \]

\[ \pi_2^m = \left[ \frac{(P_L - \alpha P_H)}{(1 - \alpha)} + \frac{\alpha \gamma (P_H - P_L)}{(1 - \alpha)} \right] \]

(11)

and the retailers profit is

\[ \pi_2^r = (1 - \gamma)P_L - W_2 \]

(12)

\[ \pi_2^r = (1 - \gamma)[P_L - \frac{(P_H - P_L)}{(1 - \alpha)}] \]

(13)

**Theorem 1:** For any price \( W_2 \) which is not equal to wholesale price in the decentralized scenario, there is a value for \( \gamma \) under the revenue sharing scenario such that both the manufacturer and the retailer have a higher profit than the realized profit under the decentralized scenario.

\[ \pi_2^m \geq \alpha P_H \]

\[ \pi_2^r \geq 0 \]

and the Revenue sharing mechanism has the potential to eliminate the channel breakdown completely (i.e. channel coordinates when \( P_L < \alpha P_H (2 - \alpha) \)).

**Proof:** For ensuring win-win the profit for both the players must be greater than what they achieve in a solitaire scenario. The manufacturers profit must be greater than the profit he obtains in the solitaire scenario:

\[ (1 - \gamma)[P_H - \frac{(P_H - P_L)}{(1 - \alpha)}] + \gamma P_L \geq \alpha P_H \]

(14)

This gives a lower bound for \( \gamma \), as
\[
\gamma \geq \frac{\alpha(2-\alpha)P_H - P_L}{\alpha(P_H - P_L)} = \gamma^-
\]  

(15)

It is essential for the value of \( \gamma \) to be greater than 0, for which the value in equation 15 is made to be greater than 0. That will happen when

\[
P_L < \alpha P_H (2-\alpha)
\]

(16)

This is exactly the region in which the manufacturer is not interested in coordination (equation 4). From the equation 16 it is possible to provide a greater profit to the manufacturer than the decentralized channel and eliminate the double marginalization completely (which means channel coordination is always possible).

The retailers profit must be greater than the profit he obtains in the solitaire scenario:

\[
(1-\gamma)P_L - (1-\gamma)\left[\frac{(P_L - \alpha P_H)}{(1-\alpha)}\right] \geq 0
\]

(17)

This gives a lower bound for \( \gamma \), as

\[
\gamma \leq 1 = \gamma^+
\]

(18)

From the above analysis we can conclude that the revenue sharing mechanism is able to coordinate the channel and provide win-win solution as long as the values of parameter value satisfies the condition obtained in equation 15. and equation 18.

For our numerical example the wholesale price can be obtained from equation 9 as \((1-\gamma)\). The manufacturer’s profit from equation 11 as \((1+\gamma)\) and the retailers profit from equation 13 is\((1-\gamma)\). The lower bound for \( \gamma \) is obtained from equation 15 is obtained as 0.5 and the upper bound from equation 18 is 1. From equation 16 the revenue sharing mechanism is feasible as long as \(P_L < 2.25\). Figure 4 represents the profit profile for the players and the supply chain for different revenue share percentages.
3.2. Profit sharing mechanism

In the profit sharing mechanism the transaction between the supplier and the buyer are governed by the supplier receiving a share of the buyer’s profits. (Jeuland and Shugan, 1983) have used profit sharing as a mechanism to achieve channel coordination. The profit sharing mechanism can be identified by two parameters, namely, wholesale price $W$ and a percentage of the buyers profit $\delta$ ($0 < \delta < 1$), that goes to the supplier.

With the profit sharing mechanism the retailers profit when he sells only to the highs is

$$\alpha(1 - \delta)(P_H - W)$$

and the retailers profit when he sells to the entire market is:

$$(P_L - W)(1 - \delta)$$

The wholesale price should be set such that the retailer is indifferent between the above two options. That will happen when the manufacturer selects the wholesale price such that retailer’s profit in equations 19 and equation 20 are equal:

$$\alpha(1 - \delta)(P_H - W) = (P_L - W)(1 - \delta)$$
The wholesale price is independent on the profit sharing percentage and interestingly it is same as the wholesale price that the manufacturer should charge for channel coordination (Equation 1). The manufacturer would be interested in supplying the product at this wholesale price as he will receive a share of retailer’s profit in addition to the wholesale price.

The profit for the manufacturer with the profit sharing mechanism can be obtained as

$$\pi_m = W_3 + \delta(P_L - W_3)$$

(23)

$$\pi_m = (1 - \delta)[V_H - \frac{(P_H - P_L)}{(1 - \alpha)}] + \delta P_L$$

(24)

and the retailer’s profit is

$$\pi_r = (1 - \delta)(P_L - W_3)$$

(25)

$$\pi_r = (1 - \delta)(P_L - [P_H - \frac{(P_H - P_L)}{(1 - \alpha)}])$$

(26)

It is interesting to note that the manufacturer and the retailer makes the same profits with both the revenue sharing and the profit sharing mechanisms as long as the conditions for the wholesale prices as obtained in equation 9 and equation 22 are satisfied.

**Theorem 2:** For any price $W_3$ which is not equal to wholesale price in the decentralized scenario, there is a value for $\delta$ under the profit sharing scenario such that both the manufacturer and the retailer have a higher profit than the realized profit under the decentralized scenario.

$$\pi_m^* \geq \alpha P_H$$

$$\pi_r^* \geq 0$$

And the Profit sharing mechanism has the potential to eliminate the channel breakdown completely (i.e. channel coordinates when $P_L < \alpha P_H (2 - \alpha)$).

**Proof:** The analysis for the profit sharing mechanism follows on the same lines as that of the revenue sharing mechanism. More importantly the range for the parameters obtained with the revenue and the profit sharing mechanisms are equivalent.
Figure 5 depicts the feasibility region for the revenue and the profit sharing mechanism. The feasibility region is indicated by a dotted line.

\[ \alpha P_H \quad \text{Decentralized= Cent.} \]

\[ \alpha(2-\alpha)P_H \quad (\text{€2.25}) \]

\[ \alpha P_H \quad (\text{€1.5}) \]

Figure 5: The feasibility region for the revenue and the profit sharing mechanism

In the next sub-section we analyze the performance of pull discount mechanism.

### 3.3. Pull promotion

A pull promotion mechanism refers to a situation in which the manufacturer offers discounts directly to the price-conscious consumers, expecting them to ask the retailer for the product. Gerstner and Hess (1995, 1991) design the pull discount mechanisms in the same setting as ours.

The use of discounts by consumers is modeled in a simple way. A consumer must exert effort to obtain the pull discount, and this effort has a monetary equivalent called the transaction cost. If the pull discount exceeds the transaction cost, the consumer uses the discount. For simplicity the lows transaction cost is normalized to zero, and the highs transaction cost is denoted by \( T \). That is, \( T \) should be interpreted as the transaction cost differential between the Highs and the Lows.

Under the pure pull promotion Gerstner and Hess (1995, 1991) assume that the wholesale price is left at the level as in the decentralized scenario, i.e. \( W' = P_H \) (Where \( W' \) is the wholesale price with the pull discount mechanism).

The manufacturer offers consumers a pull discount, \( D \). The transaction cost the Highs incur to use the discount, \( T \), is assumed to be less than \( P_H - P_L \). The pull discount gives the Highs a net price reduction of \( D - T \). The retailer calculates that Highs would be willing to pay a retail price of \( P_H + D - T \), and the Lows would be willing to pay \( P_L + D \), taking the discount into account. If the retailer is uncooperative, the retail
price could be set as high as $P_H + D_4 - T_4$ and only the highs would buy. Under cooperation the retailer adopts a price equal to $P_L + D_4$ and both Highs and Lows would buy.

The corresponding retail profits are $\alpha[(P_H + D_4 - T_4) - P_H] = \alpha(D_4 - T_4)$ without cooperation and $(P_L + D_4) - P_H$ with cooperation.

To motivate channel coordination, the profit-maximizing manufacturer adjusts the pull discount until the retailer is just indifferent between cooperating or not. To calculate this discount, set the two retail profit expressions equal and solve for $D_4$:

$$D_4^* = \frac{(P_H - P_L - \alpha T_4)}{(1 - \alpha)}.$$  \hspace{1cm} (27)

The profits for the manufacturer and retailer when cooperation is induced are,

$$\pi_m^* = P_H - D_4^* = \frac{(P_L - \alpha P_H + \alpha T_4)}{(1 - \alpha)}.$$ \hspace{1cm} (28)

$$\pi_r^* = P_L + D_4^* - P_H = \frac{[\alpha(P_H - P_L) - \alpha T_4]}{(1 - \alpha)}.$$ \hspace{1cm} (29)

and the total channel profit equals $P_L$.

The channel does not coordinate when manufacturer profit in equation 28 is smaller than the profit from selling only to highs ($\alpha P_H$). Combining these two inequalities gives the breakdown region under pure pull,

$$\alpha P_H < P_L < \alpha P_H (2 - \alpha) - \alpha T_4$$ \hspace{1cm} (30)

As concluded above the pull discount mechanism is not able to eliminate the breakdown region completely and it also fails to provide any additional profit to the retailer as the wholesale price is fixed at $P_H$. Figure 6 depicts the double marginalization range for the pull discount mechanism (Dotted arrow).
4. Targeted Push-Pull discount

In this model push refers to a long-run reduction in wholesale price designed to complement the pull and to induce the retailer permanently to sell to the low willingness-to-pay consumers. With this mechanisms, the profit-maximizing manufacturer will pick a pull discount to the High’s transaction costs.

\[ D_s^* = T_s \]  

(31)

Given this discount, the highest retail price that induces all customers to buy the product is

\[ P = P_L + T_s \]  

(32)

To find the equilibrium wholesale price, note that the retail profit equals \( P = P_L + T_s - W_s \), when the retailer acts cooperatively. The retail price that maximizes the retailer’s profit when he threatens to sell only to the Highs is \( P_H \), and the resulting profit equals \( \alpha(P_H - W_s) \). To induce retail sales to the lows, the manufacturer offers the discount given in the equation 31 and adjusts the wholesale price until the retailer is just indifferent between selling to all customers and selling only to the Highs. Setting the two retail profit expressions equal and solving for the wholesale price gives

\[ W_s = \left[ P_H - \frac{(P_H - P_L - T_s)}{(1 - \alpha)} \right] \]  

(33)

If the manufacturer wanted to sell only to the Highs, the wholesale price would be equal to \( P_H \). As a result, pricing by the manufacturer involves a push as well as a pull. The
retailer is offered a price reduction of the amount \( \frac{(P_H - P_L - T)}{(1 - \alpha)} \) where as the consumers are offered a discount of \( T \).

Using equations 31 and 33 and keeping in mind that the retail price is \( P_L + T \) and that the discount is paid only to the Lows, the manufacturer and retailer’s profits are

\[ \pi^* = W - (1 - \alpha)T = \frac{(P_L - \alpha P_H + \alpha(2 - \alpha)T)}{(1 - \alpha)} \tag{34} \]

\[ \pi^* = P_L + T - W = \frac{\alpha(P_H - P_L) - \alpha T}{1 - \alpha} \tag{35} \]

And the channel profit is \( P_L + \alpha T \).

Gerstner and Hess (1995, 1991) has performed the above analysis on the combined push pull discount and arrived at the bounds for \( P_L \) between which the push-pull strategy fails to repair the breakdown in channel price coordination. The bounds are obtained as,

\[ \alpha(P_H - T) < P_L < \alpha P_H (2 - \alpha) - \alpha T (2 - \alpha) \tag{36} \]

From the equation 36 we can obtain a condition on the minimum transaction cost value below which the channel fails o coordinate. The channel fails to coordinate when the transaction cost values satisfies the following condition:

\[ T < \frac{\alpha(2 - \alpha)P_H - P_L}{\alpha(2 - \alpha)} \tag{37} \]

For our numerical example the combined pull discount fails to coordinate when the value of \( T \) is less than $0.33. Figure 7 depicts the double marginalization range for the targeted push-pull discount mechanism.
The next sub section analyses the effectiveness of the revenue sharing in combination with the targeted pull discount.

### 4.1. Targeted Pull with Revenue sharing

In this sub section we combine revenue sharing with the targeted pull discount in which only the Lows make use of the discount. The retailer’s profit when he decides to sell only to the highs is:

\[ \alpha(P_H - W_6) - \gamma \alpha P_H \]  

(38)

Where \( \gamma \) is the percentage of the revenues that the retailer shares with the manufacturer, and the retailer’s profit when he sells to the entire market is:

\[ P_L + T_6 - W_6 - \gamma(P_L + T_6) \]  

(39)

The wholesale price should be set such that the retailer is indifferent between the above two options. That will happen when we make the equations 38 and 39 as equal.

\[ \alpha(P_H - W_6) - \gamma \alpha P_H = P_L + T_6 - W_6 - \gamma(P_L + T_6) \]  

(40)

\[ W_6 = (1 - \gamma)\left[\frac{(P_L + T_6 - \alpha P_H)}{(1 - \alpha)}\right] \]  

(41)

Equation 41 gives the wholesale price with the revenue sharing in combination with targeted pull mechanism. The wholesale price is dependent on the percentage of the revenues shared and it is a decreasing function of the percentage of revenues shared. The profit for the manufacturer with the revenue sharing mechanism can be obtained as:

\[ \pi^m_6 = W_6 + \gamma(P_L + T_6) - (1 - \alpha)T_6 \]  

(42)
\[
\pi^m_6 = \frac{(P_L + T_6)(1 - \gamma\alpha) - \alpha P_H (1 - \gamma) - (1 - \alpha)^2 T_6}{(1 - \alpha)}
\]  
(43)

And the retailer's profit is:

\[
\pi'_6 = (1 - \gamma)(P_L + T_6) - W_6
\]  
(44)

\[
\pi''_6 = (1 - \gamma)\left[\frac{\alpha(P_H - P_L) - \alpha T_6}{(1 - \alpha)}\right]
\]  
(45)

**Theorem 3:** A targeted pull discount mechanism in combination with the revenue sharing mechanism will coordinate the channel when the targeted push-pull mechanism fails to do so.

**Proof:** The manufacturer's profit must be greater than the profit he obtains in the solitaire scenario:

\[
\pi^m_6 \geq \alpha P_H
\]

\[
\pi'_6 \geq 0
\]

With the coordinating wholesale price \((W_6)\) there exists a value \(\gamma\) such that both the players make a greater profit than the decentralized scenario.

\[
\pi^m_6 \geq \alpha P_H
\]

\[
\pi'_6 \geq 0
\]

\[
\pi''_6 \geq 0
\]

The upper bound for \(T_6\) will be obtained as
Comparing equation 37 and equation 49 it is clear that revenue sharing mechanism in combination with the pull discount works when the combined push-pull mechanisms fails to coordinate.

\[ T_6 \leq \frac{\alpha(2-\alpha)P_H - P_L}{\alpha(2-\alpha)} \quad (49) \]

This gives a lower bound for \( \gamma \), as

\[ \gamma \leq 1 = \gamma^- \quad (51) \]

And when the second part of the equation 50 is made positive the following threshold on the transaction cost is obtained:

\[ \left[ (P_L + T_6) - \left( \frac{(P_L + T_6) - \alpha P_H}{1 - \alpha} \right) \right] \geq 0 \quad (52) \]

The following condition on \( T_6 \) can be obtained from equation 52:

\[ T_6 \leq \frac{P_L - \alpha P_H}{\alpha(1-\alpha)P_L} \quad (53) \]

The Lower bound on \( T_6 \) is the smaller value of equation 49 and Equation 53. It is very easy to verify that equation 53 will always be greater than 49. The interesting part of the entire analysis is the restriction on the \( T_6 \) value for the revenue sharing percentage \( \gamma \) to be positive. Interestingly the possibility of combining the contract mechanisms with the targeted pull discount will help the channel to coordinate when it fails with targeted push-pull discount mechanism.

For our numerical example the wholesale price can be obtained from equation 41 as \( 1.5(1-\gamma) \). The manufacturers profit is obtained from equation 43 as \( (1.5 + 0.75\gamma - 0.5T_6) \). The retailers profit can be obtained from equation 45 as \( 0.75(1-\gamma) \). The lower bound for \( \gamma \) can be obtained from equation 47 as \( 0.67T_6 \). The upper bound for \( \gamma \) can be obtained from equation 51 as 1. The value of \( T_6 \) should be the minimum of the equation 49 and 53 and for our numerical example the minimum from
those two equations is 0.33. Interestingly, this is also the range where the push pull discount mechanism fails to coordinate the channel.

The next sub section analyses the pull discount mechanisms in combination with the profit sharing mechanism.

4.2. Targeted pull with the profit sharing mechanism

The present analysis tests the applicability of the profit sharing mechanism in combination with the targeted pull discount. Profit sharing mechanisms is combined with the targeted pull in which only the Lows make use of the discount as the discount value is the same as the High’s transaction cost.

The wholesale price with the profit sharing mechanisms can be obtained as:

\[ W_\gamma = [P_H - \frac{(P_H - T_\gamma - P_L)}{(1-\alpha)}] \]  \hspace{1cm} (54)

**Theorem 4:** A targeted pull discount mechanism in combination with the profit sharing mechanisms will coordinate the channel when the targeted push-pull mechanism fails to do so.

i.e. when \( T_\gamma < \frac{\alpha(2-\alpha)P_H - P_L}{\alpha(2-\alpha)} \)

With the coordinating wholesale price \((W_\gamma)\) there exists a value \( \delta \) such that both the players make a greater profit than the decentralized scenario.

\[ \pi_\gamma^m \geq \alpha P_H \]
\[ \pi_\gamma^c \geq 0 \]

The proof for theorem 4 follows on the same lines as that of the revenue sharing mechanism. Equivalence relationship can be obtained for all the parameter values and like the revenue sharing mechanism, combining profit sharing mechanisms with the push discount mechanism coordinates the channel when the push-pull discount mechanism fails to do so. The feasibility region with both these mechanisms is very well depicted in figure 8 (Dotted arrow).
In the next section we conclude our study and provide some managerial insights.

5. Conclusions and managerial implications

The present study provides the following interesting insights:

1) When all the customers can make use of the discount then revenue and profit sharing mechanisms eliminate channel breakdown completely thus coordinating the channel. Pull discount mechanism reduces the breakdown region but does not eliminate it completely.

2) For the considered supply chain setting both the revenue and profit sharing mechanisms are equivalent. Same values for the profits and parameters are obtained with both the mechanisms.

3) Targeted pull discount, in combination with the revenue or profit sharing mechanism is feasible only when the transaction cost is below a certain threshold. Interestingly, this is exactly the region in which Targeted push-pull discount breaks down.

From an implementation point of view the contract mechanisms will not be more difficult than that of the pull discount mechanism, as these contracts have to be dealt with a single retailer as opposed to an entire customer base in pull discount. Implementing pull discount along with the revenue sharing requires a greater effort, and would be worthwhile if the benefits to the channel are greater than the costs associated with implementing such a contract.

References


