Abstract

This paper investigates a supply chain that consists of a manufacturer and a retailer where the retailer determines the retail price and customer service level while experiencing customer returns and price dependent stochastic demand. We propose an agreement between the manufacturer and the retailer that includes VMI partnership and sales rebate contract. VMI facilities the application of the sales rebate contract since information sharing in VMI allows the supplier to obtain actual sales data. We consider two forms of sales rebate in the model, linear rebate and target rebate. Because of a proper rebate contract, the retailer lower price to the system-wide optimal prices so as to increase demand a further improve the aggregate chain profit. We study two different forms of sales rebate contract and show that these two agreements can achieve perfect supply chain coordination.

Keywords
Target Rebate, Linear Rebate, VMI, Consumer Return Policy, Supply Chain Management

1. Introduction

Returns of product from customers to retailers are a common feature of competitive markets. The volume of returns in North America is significant and growing: Stalk reported that returned goods are estimated to exceed $100 billion per year in the united states and in many categories, the number of returns is growing at better than 50% a year[1]. Returns rates are also high for example typical returns rate ranged from 1% to 5% for business products, to as high as 25% to 40% for high-fashion apparel [2]. In retail industries, a returned item is differently handled, depending on the status of the product and the relationship between retailers and manufacturers. If the item is not apparently damaged, it will go back to the shelf. However, if the manufacture desires to keep a high standard, the item will not go back to the shelf until the manufacturer inspected the product. For example, welding equipment HP and Bosch follow this policy [2].

The presence of product return adds one dimension to the relationship between manufacturers and retailers underscores the importance of coordination. To improve the efficiency of a decentralized supply chain, the supply chain requires the collaboration of the players who independently maximize their own profit. Supply chain coordination may be achieved by modifying the structure of these relationships. Coordination of supply chain is
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imperative for improving its performance. By applying contractual relationships among members of a supply chain double marginalization can be eliminated.

Contract is an effective tool to allocate the channel profit between the players. Another important function of contract is that it facilitates a long-term partnership and makes the terms more explicit. Various contract has been proposed to coordinate the supply chain by aligning objectives of the supply chain members.

The sales rebate contract is one of the contracts that coordinate the supply chain with one compliance regime, and channel rebates are widely adopted in the hardware, software and auto industries. A channel rebate is a payment from a manufacturer to retailer based on retailer sales to end consumers. The manufacturer’s objective is to increase sales motivation of the retailer and to decrease the quantity of returned goods. The rebate contract has the effect of motivating retailer to lower prices for increasing sales, so it is a good application for system coordination.

However, it is difficult to implement a sales rebate contract in a traditional supply chain, mainly because a traditional supply chain does not have a mechanism to facilitate continuous information exchange between chain members. The supplier needs to know the exact quantity sold by the retailer in order to pay the rebate but difficulties arise when the supplier cannot acquire the retailer’s sales data directly. On the other hand, the data obtained from the retailer may not be authentic as the retailer may claim more rebates than what the actual sales allow. Difficult administration is probably the reason for a preference for other contract such as wholesale price over a sales rebate, despite the fact a sales rebate is better sales incentive.

As market competition becomes more intense, firms are turning their attention more towards cost reduction, instead of focusing solely on revenue generation. For many industries such as power plants, a major source of cost is supply chain inventory. The value of parts which are kept in warehouse is usually more than 7 million dollars [3]. The cost of inventory can be reduced and product availability may be improved if a company improves its relationship with suppliers. The VMI is an effective tool to delegate the inventory decision to the supplier rather than seller. VMI is an important flow coordination scheme which integrates operations between suppliers and seller through information sharing and business process reengineering [4]. Buzzell reported that the implementation of VMI partnership at Dillard Department Stores, JCPenny, and Wal-Mart increased the sales performance by 20-25% and improved the inventory turn by 30% [5]. The benefits of this relationship to the partners in the channel are to better control supply chain variability, reduce inventory and deteriorated goods and then increase profit [4].

Although the sales rebate contract and VMI partnership and supply chain return policy is widely investigated, few researches integration them. In view of this gap in the literature we integrate consumer return and sales rebate contract and VMI partnership second; we investigate the effects of consumer return on coordination mechanism and the expected profits of the player.

As retail pricing is important factor that determine the success of a supply chain, one major objectives of this paper is to study supply chain coordination when the retailer has to choose retail price to increase sales. Our major research questions are: can the combination of linear rebate contract with VMI or target rebate contract with VMI coordinate the supply chain that faces consumer return and price dependent demand? How to decide the optimal contracts parameters to achieve supply chain coordination?

The rest of this paper is organized as follows. In the next section, we review the related literature. Section 3 introduces the model assumptions and notations and centralized channel as benchmark case. In section 4 we analysis joint sales rebate and VMI. Section 5 summarizes the results.

2. Related Research

This paper is closely related to supply chain coordination management, VMI, consumer return policy. Coordination among suppliers and retailers is a very important strategic issue in supply chain management [3]. The concept of coordination may guide supply chain members to work coherently to identify inter-dependencies between each other, to mutually define goals and to fairly share risks and reward [4]. Whang has classified the coordination from an organizational perspective in terms of single-person, team-based and nexus-of-contract approach [5]. Sahin and Robinson proposed price, non-price, buyback, quantity flexibility, allocation rules, and information sharing and flow coordination as major categories of coordination mechanisms [6]. The classification can therefore be summarized as flow coordination and contract-based coordination. Supply chain contract is a set of many clauses
that offers suitable information and incentive mechanism to guarantee all supply chain members to achieve coordination and optimize the supply chain performance.

Various types of contracts have been established to coordinate chain members and allow individual decisions to be aligned with the whole system’s objective through an agreement reached by the supply chain members. Cachon did a detailed survey of coordination with contracts and kinds of contracts effects on the supply chain coordination for a wide range of supply chain model [7]. The marketing and economics literature have investigated the use of retailer rebate. Gerstner and Hess have examined how retailer and consumer rebate induce the retailer and how such promotions influence manufacturer and channel profits [8]. Krishnan et al. have focused on the use of retailer rebates in the presence of retailer efforts claimed that rebates always benefit the manufacture [9]. Taylor has considered retailer rebates in a model where demand is stochastic, but the retail price is exogenously given. The author has demonstrated that the sales rebate contract that does not coordinate on its own, can coordinate the channel if it is combined with buyback contract [10]. Chen incorporate buyback contract with consumer return policy in a decentralized supply chain where retailer simultaneously determine retail price and order quantity and faces dependent stochastic demand [2].

Our model is similar in some sense to the one studied by Taylor. However, in Taylor’s model the retail price is assumed to be exogenous. We extend Taylor’s model by allowing the price to become a decision variable for the retailer. Besides the rebate considered in Taylor, we also consider consumer return policy in the model and use combined contract with VMI that inherit the advantages of sales rebate and VMI partnership.

3. The Model Assumptions and Centralized Supply Chain with VMI

3.1 Model Assumption
Consider a supply chain where a supplier produces a product and sells it through a retailer \( R \). The supplier produces the product at a constant unit cost of $c$ and sells it \( w \). Market demand for the product during a selling season, is sensitive to retail price. The supplier, knowing the characteristics of demand, need to decide contract format and parameters to achieve the best performance so entire supply chain. Is probability density and \( p \) is cumulative distribution of demand random variable that is differentiable, invertible, and strictly decreasing in price. We use a multiplicative model to capture the randomness in the demand. Thus we model the demand for the product at retailer.

\[
D(p, \epsilon) = D(p) \epsilon
\]  

Where \( p \) the retail price is charged by retailer to consumers, \( D(p) \) is the expected demand at retail and \( \epsilon \) is a random scaling factor, representing randomness of demand, with a mean value of 1. \( D(p, \epsilon) \) has a general distribution with the continuous cumulative distribution function \( F(s|p) \), which is differentiable in the retail price \( p \), and having density function \( f(s|p) \). The retailer determines the retail price based on the wholesale price of the supplier and set the minimum CSL. The supplier produces \( Q \) units of the product under the given CSL and delivers them to the retailer who then rises to sell them to the market at the retail price \( p \) during the selling season. Retailer offers a refund amount \( \alpha \) to consumers when the product is returned. The retailer incurs a handling cost \( s \) per unit return of consumer. Consumers return the products with probability \( \alpha \). At the end of the selling season, the product that has not been sold or returned product has a unit salvage values. Underage cost is \( g \) per unit of unmet demand and there is an average cost of \( h \) per unit of unsold inventory.

The following sequence of events takes place:

- The supplier, acting as a leader, offers a contract specifying the terms of payment to him from the retailer upon sale of items to consumers
- Each retailer acting as a follower, chooses the retail price base on the wholesale price of the supplier and set the CSL
- Before the start of selling season, the supplier produce \( Q \) units of the product under the given CSL and delivers \( Q \) units to retailer
- Demand realized and number of products returned.
- Transfer payments are made between supplier and retailer according to the agreed contract
In this study, we define the number of returns as:
\[ R(D(p,e), Q) = \alpha \min\{D(p,e), Q\} \]
(2)

We assume that the customer receives a full refund for returned product from the retailer.

3.2 Centralized Channel with VMI

The retailer determines an inventory level in order to maximize the profit. By the constraint of the CSL required by retailer, the supplier replenishes products with quantities for retailer as below:
\[ Q = d(p)G^{-1}(CSL) = d(p)k \]
(3)

The expected profit of the integrated supply chain under VMI partnership is:
\[ E[\Pi_1(p, Q)] = (p(1-a) - sa - c)Q - (p(1-a) - sa + h)E[Q(D(p,e))]^+ - gE(D-\xi)^+ \]
(4)

There exists a unique optimal price if
\[ \frac{\partial E[\Pi_1(p, Q)]}{\partial p} \geq 0 \quad \text{for} \quad p>0 \]

For the case of linear demand, \( D(p) = a - bp \) with \( a>0, b>0 \), there exists a unique optimal price \( (p^*) \)
\[ \frac{\partial E[\Pi_1(p, Q)]}{\partial p} = -2b(1-a)(k-A) \leq 0 \quad \text{for} \quad p>0 \]
\[ A = \int F(x) dx \]

for the integrated supply chain, from (4) we obtain the optimal price
\[ p^*_{\text{SC-vmi}} = \frac{1}{2(1-a)} \left( \frac{a(1-a)}{b} + s \alpha - g + \frac{(Kc + Ah)}{(K-A)} \right) \]
(7)

The optimal price \( (p^*) \) is increasing function of \( a \) since
\[ \frac{\partial p}{\partial a} = \frac{s}{2(1-a)^2} + \frac{2(k-A)(Kc + Ah)}{4(1-a)^2(K-A)^2} \geq 0 \]
(8)

Consequently, profit function is decreasing in \( a \) since
\[ \frac{\partial \pi}{\partial a} = (p + s)(A-K)d(p) \leq 0 \]
(9)

4. The Decentralized Supply Chain under VMI and Contract

A supply chain involves managing various resources such as inventory, money and information between disparate but dependent chain members. The conflicting objectives and lack of coordination between supply chains may often cause uncertainties in supply chain. The centralized control of supply chain assures coordination but it may not be realistic, whereas in decentralized control, supply chain members optimize local decisions without considering the impact of their decisions on the other member’s performance and overall performance of supply chain. Hence, some coordination mechanism is necessary utilizing which may motivate the members to achieve coordination. In the rest of this part, we model problem with different kind of sales rebate contracts, namely linear rebate and target rebate.

4.1 Linear Rebate with VMI Partnership

The sales rebate contract is one of the contracts regimes, and channel rebates are widely adopted in the different industries. A channel rebate is a payment from a manufacturer to a retailer based on retailer sales to end consumers. The rebate contract has the effect of motivating retailer to lower prices for increasing sales, so it is a good application for system coordination. \( r \) is a reward paid by the supplier to the retailer for each unit sold.

Under the linear rebate contract, the retailer’s profit function is
\[ \pi_R(P, Q) = \left[ (p-w+r)(1-a) - sa \right]Q - \left[ (p-w+r)(1-a) - sa \right]E[Q(D(p,e))]^+ - gE[Q(D(p,e)) - Q]^+ \]
(10)
There exists a unique optimal price \( \frac{c_\pi R(P, Q)}{c_\pi^2} = -2b(1-\alpha)(k - A) \leq 0 \)

The retailer’s optimal price can be expressed as the function of the supplier price:

\[
P_R^* = \frac{1}{2(1-\alpha)} \left[ a(1-\alpha) b + (w-r)(1-\alpha) + s\alpha - g \right]
\]

(11)

To achieve supply chain coordination should be \( P_R^* = P_{Sc-vmi}^* \) thus, the relation of the wholesale price and the rebate must satisfy

\[
\frac{w^*_L}{w^*} = r + w^0
\]

(12)

Thus supply chain, with customer returns that are proportional to sales, can be coordinated using a linear rebate agreement. There exists a wholesale price/rebate scheme coordinating the channel which allows the supplier to earn positive profit. The VMI mode helps to implement the rebate contract through monitoring the retailer’s inventory by obtaining sales data easily. As the quantity is known to the supplier, it takes less administration cost for the supply chain to adopt the rebate contract. The VMI mode avoids the retailer overstating the sales data for gaining more rebates as happened in RMI. Therefore, VMI provides more favorable conditions to implement the rebate contract than RMI. In the coordination scheme, there are two correlated variables \( w, r \) which depends on each other. In short, \( w \) is increasing with respect to \( r \). To investigate the impact of the customer returns on pricing, we note that \( \lim \alpha \to 0 \) provides the optimal price \( P_0^* \) for the case of no return:

\[
P_0^* = \frac{1}{2} \left[ \frac{a}{b} + (w-r) - g \right]
\]

(13)

We note that \( P_R^* - P_0^* = \frac{a(s-g)}{2(1-\alpha)} \) it is reasonable to assume that \( s > g \), in which case \( P_R^* > P_0^* \). The optimal price is an increasing function of \( \alpha \) since \( \frac{\partial P_R^*}{\partial \alpha} = \frac{s - g}{2(1-\alpha)^2} > 0 \)

\[4.2. Target Rebate with VMI Partnership\]

The target rebate is in one kind of reward mechanism. The target rebate is that the manufacturer will provide the retailer the unit bounty only when retail merchant’s actual sales volume is bigger than the target sale quantity which is formulated by manufacturer [11].

Under the sales rebate contract and VMI, the retailer’s profit function is

\[
\pi_G(P, Q) = [(p-w)(1-\alpha) - s\alpha][Q - [(p-w)(1-\alpha) - s\alpha][Q - D(p, e)]^+ + r[s(q)-T]^+ - gE[D - Q]^+
\]

(14)

\[S(q) \] is expected sales.

There exists a unique optimal price, since

\[
\frac{c_\pi R(P, Q)}{c_\pi^2} = -2b(1-\alpha)(k - A) \leq 0
\]

(15)

The retailer’s optimal price can be expressed as the function of the supplier price:

\[
P_R^* - T = \frac{a}{2b} \left[ \frac{w}{2} + \frac{s\alpha}{2(1-\alpha)} \right] + \frac{r + g(k-A)}{2(1-\alpha)}
\]

(16)

We note that \( \lim \alpha \to 0 \) provides the optimal price \( P_0^* \) for the case of no return:

\[
P_0^* = \frac{1}{2b} \left[ \frac{a}{2} + (w-r) - g \right]
\]

(17)
We note that \( p^*_R - p_0^* = \frac{s \alpha - r - g(k - A) + (r + g)(1 - \alpha)}{2(1 - \alpha)} \) it is reasonable to assume that \( s > g \), in which case \( p^*_R > p_0^* \).

The optimal price is an increasing function of \( \alpha \) since

\[
\frac{\partial p^*_R}{\partial \alpha} = \frac{s - g}{2(1 - \alpha)} > 0
\]

To achieve supply chain coordination \( p^*_R \) should be equal to \( p^*_{\text{vimi}} \), the optimal price to maximize the chain wide profit, which is solved by the following equation.

\[
r = W^*_T - Kc - \frac{Ah}{b} \quad \text{or} \quad W^*_R = r + Kc + \frac{Ah}{b}
\]

The equation (19) implies that \( r < w \) and \( r + c < w \) thus target rebate scheme with \( r < w \) are very aligned with manufacturer objectives.

From (11) and (16) we can find that

\[
p^*_R - p^*_R = \frac{g(K - A + 1) - r}{2(1 - \alpha)} \leq 0
\]

If \( r < g \) then the retailer’s expected profit under target rebate is a larger than a linear rebate.

If rebate amount \( r \) is assumed constant, from (12) and (19) we find \( W^*_L \leq W^*_T \), if \( A < K < A + 1 \) hence supplier expected profit under linear rebate is a larger than a target rebate.

5. Conclusion

In this paper, we study coordination of a two-echelon supply chain that retailer faces price dependent stochastic demand and consumer return. With the increase of product variety, consumers feel much uncertain about whether specific items fit their needs. If the items don’t fit, consumers wish return them. We considered joint sales rebate with VMI partnership. Rebate contract to encourage the retailer to increase sales quantity as well as promote profits of the whole supply chain. However, it is difficult to implement a sales rebate contract in a traditional supply chain, mainly because a traditional supply chain does not have a mechanism to facilitate continuous information exchange between chain members. The supplier needs to know the exact quantity sold by the retailer in order to pay the rebate. In this paper, two different types of rebate namely linear rebate and target rebate combine with VMI partnership. We find these arrangements can coordinate supply chain also we find retailer’s expected profit under target rebate is a larger than a linear rebate if rebate amount be less than shortage cost.

References