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Study on supply chain coordination under Retail Competition and Consumer Return

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Abstract
Consumer return policy is common in recent years. The presence of product return adds one dimension to the relationship between manufacturers and retailers and underscores the importance of coordination. Consignment contracts have been widely employed in many industries. Under such contract the retailer returns the unsold and returned products to the supplier. This paper investigates how competition among retailers influences the supply chain decisions and profits under this contract and consumer return policy. We find that the retailers benefit more from the consignment contract than from a price only contract.

Keywords: competition, consignment, return policy, supply chain

1. Introduction

With the increase of product variety, consumer feels much uncertain about whether specific items fit their needs or match their tastes. If the items do not fit, the consumer may return them. When a consumer purchases a product, firms typically offer money-back guarantees to ensure consumer satisfaction. This policy stimulates the market demand by signaling high quality. However, they may incur excess inventories and handling costs for firms when items are returned [1].

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, a major source of cost is supply chain inventory. Consequently, how to manage supply chain inventory has been one of the major tasks to purchasing and supply chain management professionals. Consignment contract is one of mechanisms to improve overall chain performance. This contract is widely used in industries with short life-cycle products such as fashion apparel, books, and toys [2].under such a contract, ownership of the goods is retained by the supplier. With Consignment contract, the supplier offers a consignment price charged to the retailer for each unit of product sold and the retailer chooses a retail price for selling the product to the market and inventory level. The main objective this contract is to mitigate the risk of overstocking faced by the retailer, which is caused by the uncertain nature of the retail demand.

Our research focuses on a consignment contract and return policy under retail competition. In order to understand the impact of these this contract, price-only contract is used as benchmark to evaluate buyback contract. Our research quantifies the benefits to all members of the supply chain under different contract setting and helps determine which contracts terms are most beneficial to the entire system as well as to different parties involved.

The purpose of this study is to investigate the effect of retail competition on the decision making of supply chain members and the channel performance under consignment contract and return policy. The results of the study are used to answer the following research question:

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1- How do consignment contract compare with price-only contract from the entire system's perspective?
2- How do the presence of competition among retailers and the level of retailer differentiation affect decisions such as retail prices and quantity?

The rest of this paper is organized as follows: in section 2 we review briefly related literature then in section3 introduce model assumptions and notations. In Section4, we analyze price only contract and consignment contract. Section 5 providing concluding remarks.

2. Related literature

This paper is closely related to consumer returns policy, and consignment contract and retail competition. We briefly review relevant literature in these areas.

Returns of product from customers to retailers are a common feature of competitive markets. Some consumers return products that perform unsatisfactory while others return products that function satisfactorily for other reasons, such as not meeting expectations or tastes. Toktay stated that customer return rates ranged from 5% to 9% of sales for most retailers [2]. Different functions of consumer returns policy have been highlighted in recent years. When there are substantial transaction costs. Arcelus shows that generous return policy helps to signal high quality [3]. Chen and bell showed that customer returns affect the firm's pricing and inventory decisions, when the manufacturer and retailer are independent [1]. However the return policy may result in surplus inventory for the retailer and it may lead to inflated retail orders [4].

Our work is closely related to the literature on consignment contract within supply chain. Wang propose a single product consignment contract with revenue sharing between a supplier and a retailer. The retailer first decides the fraction of the revenue to keep for each unit sold; the supplier then chooses the retail price and the quantity placed at the retailer's. The authors assess the impact of retailer's share of the channel cost and the demand-price elasticity on channel profits. They conclude that the loss of profit in a decentralized supply chain decreases with the retailer's cost share and increases with the demand price elasticity [5]. Li extend consignment contracts to a supply chain with multiple suppliers of complementary products and a single retailer [2]. Adida propose a consignment contract between a supplier and two retailers. He finds that the retailers benefit more from consignment price contract than from a consignment contract with revenue share or a price only contract [6].

The effect of competition in a consignment setting has been recently discussed. Wang investigates the equilibrium price and stocking of multiple suppliers and the revenue share decision of the retailer. He concludes that competition among suppliers leads to higher product prices and lower quantities [7]. Zhang extends the work by Wang by including competition between two manufacturers producing substitutable products. He finds that higher products substitutability benefits the retailer [8].

Our model is similar in some sense to the one studied by Adida and Chen [6], [1]. However in Adida's model doesn't consider the return policy also Chen's model doesn't consider competition between retailers and consignment contract.

Although consignment contract and return policy is widely investigated, few researches integrate them. In view of this gap in the literature, there are two main contributions in this paper: first, we integrate consumer return and consignment contract in a supply chain setting. Second we investigate how competition among retailer influences the supply chain decisions and profits.

3. Model assumptions

Consider a supply chain where a supplier produces a product and sells it through a two retailers (R_1 and R_2). The supplier produces the product at a constant unit cost of $\$c$ and retailer i incurs a unit cost of $\$c_{R_i}$, $i=1,2$ for handling and selling the product to consumer. Define $C=C_S+C_{R_1}+C_{R_2}$ as the total unit cost for the channel, and $\alpha_i=c_{R_i}/c$ as the share of the cannel cost that is incurred at retailer i, $i=1,2$. Note $\alpha_1+\alpha_2 \prec 1$.

Market demand for the product during a selling season, denoted by $D_i(p)$ where $p=(p_1,p_2)$, is price-dependent as well as uncertain. We use the following multiplicative function form to model demand.

$$D_i(p) = y_i(p).\varepsilon \qquad i=1,2 \qquad (1)$$

Where P is the selling price, $y(p)$ is a deterministic and decreasing function of P, $\partial y(p)/\partial p \le 0$ and ε is a scaling factor, representing the randomness of demand with expect $E[\varepsilon]=1$. Let $\varepsilon \in [A,B]$ and F(.) and f(.) be its CDF and PDF, respectively. Further, we assume $y_i(p)$ takes form (2), where β is a price sensitivity parameter and P is the retail price, adopted in several studies in literature that representing an iso-elastic demand curve [9].

$$y_i(p) = ae^{-\beta p_i + \gamma p_{-i}} \qquad a,\beta,\gamma \succ 0\,;\ \beta > \gamma \qquad (2)$$

Note that the expected demand at retailer i is a decreasing function of the retailer's own price P_i and an increasing function of its competitor's price P_{-i}, where $-i=2$ if $i=1$ and $-i=1$ if $i=2$

In this formulation a is the primary demand of each retailer, β is each retailer's own price sensitivity of demand, and γ is the price sensitivity of demand with respect to the competitor's price. The assumption $\beta > \gamma$ indicates that sales at a given retailer are relatively more sensitive to price changes at the same retailer than at the competitor's, which is a standard assumption in economics when sellers are differentiated. Parameter γ is related to the level of retailer differentiation.

Similarly to Petruzzi, we impose a mild restriction on the demand distribution known as the increasing failure rate condition also we make the assumption that the supplier offers the same contract terms to the two competing retailers [10].

Given the returns policy of the retailer, consumers will first attempt to purchase the product and then decide whether to return it after learning their own valuations. We assume that consumers return the products with probability G_1 and will eventually keep the products with probability $\overline{G}_1 = 1 - G_1$. retailer offers a fix refund amount $r \in [0,P]$ to consumers.

We model the decision making of this two-tier supply chain as supplier Stackelberg game. The following sequence of events takes place: (1) supplier offers a contract specifying the terms of payment to him from retailers upon sale of items to consumers. (2) each retailer acting as a follower , chooses the quantity Q_i to order from the supplier and the retailer price P_i; (3) before the start of selling season, the supplier produce $Q = Q_1 + Q_2$ units of the product and delivers Q_i units to retailer i, $i=1,2$; (4) demand realized and transfer payments are made between supplier and retailers according to the agreed contract. For simplicity, we assume returning probability G_1 and refund amount r for two retailers are equal.

In this study, retailers simultaneously decide their prices and stocking quantities. The next sections present equilibrium solutions for two types of contracts.

4. Contracts

4.1price-only contracts

In price only contracts, the retailers have full ownership of the inventory and thus bear all the risks for all unsold units and returned products. In this type of contract, the supplier charges each retailer a wholesale price w_p per unit ordered. We use the price only contracts as a benchmark for evaluating the performance of consignment contracts. The sequence of events is as follows.

(1) The supplier specifies the wholesale price w_p for each unit ordered

(2) Each retailer i simultaneously selects the retail price p_i and order quantity Q_i

(3) Demand is realized.

We find the equilibrium solution by using backward induction. We first derive each retailer's best response price and inventory quantity to the supplier's wholesale price decision.

4.1.1 Retailer i's selling price and stocking factor best response

At the second step of the decision sequence, for a given wholesale price w_p selected by the supplier, retailer i selects the retail price p_i and order quantity Q_i to maximize her own expected profit:

$$\pi_{R_i}(P,Q) = p_i E(\min(y_i(p)\varepsilon, Q_i)) - (c\alpha_i + w)Q_i + (p_i - r)G_1 E(\min(y_i(p)\varepsilon, Q_i)) \quad (3)$$

We define $Q_i = y_i(p)z_i$. Using z_i as a decision variable instead of Q_i [10]. We can rewrite retailer i's profit function as

$$\pi_{R_i}(P,Q) = y_i(p)\{[p_i \overline{G}_1 + (p_i - r)G_1][z_i - \Lambda(z_i)] - (c\alpha_i + w)z_i\} \quad (4)$$

Where $\Lambda(z) \equiv \int_A^{z_i} (z_i - \varepsilon) f(\varepsilon) d_\varepsilon$ and $\varepsilon \in [A,B],\ z \in [A,B]$,

To find the best response, denoted by (z_i, p_i) that maximizes $\pi_{R_i}(P_i, Q_i)$ for a given w_p, we first derive the retailer's best response retail price $p_i^*(z_i|w_p)$ for a given stocking factor z_i; we then find the best response stocking z_i^* that maximize $\pi_{R_i}(P_i^*(z_i|w_p), z_i|w_p)$. note that z_i^* and p_i^* are functions of w_p but we omit to explicitly show the dependency to keep the notation simpler. The results are summarized in the following propositions.

Proposition 4.1 for any given stocking factor z_i, wholesale price w>0 and price P_{-i} of retailer i, retailer i's unique best response price P_i^* is given by

$$p_i^*(z_i|w) = \frac{(c\alpha + w_p)z_i}{z_i - \Lambda(z_i)} + \frac{1}{\beta} + rG_1 \quad (5)$$

Proposition 4.1 implies in particular that each retailer's best response price (for a given z_i and w_p) is independent of the competitor's price decision. A price strategy that is independent of the competitor's is a property that appears in pervious literature [6].

According to Proposition 4.1, for a given stocking z_i and w_p, retailer i's best response retail price $p_i^*(z_i|w_p)$ consists of three components: the first component $1/\beta$ is relate to the sensitivity of consumers to price changes, and the second component $\frac{(c\alpha_i + w)z_i}{z_i - \Lambda(z_i)}$ reflects the retailer's costs, third component rG_1 reflects the retailer's returned costs. That is, the wholesale price paid to the supplier and the holding cost, for each unit ordered and refund cost for each unit returned product. The first component increases in β because as consumers become more sensitive to price changes, the retailer lowers the price. The second component increases proportionately to the total cost per unit. Specifically, the effect of the retailer's costs on the retail price depends upon the $\frac{z_i}{z_i - \Lambda(z_i)} = \frac{y_i(p)z_i}{y_i(p)[z_i - \Lambda(z_i)]}$, representing the ratio of expected demand to the expected quantity sold. If this ratio is high, meaning that the retailer incurs a higher risk of over-ordering merchandise, then the retailer increases the retail price. The third component increases to the returning probability G_1 and refund amount.

Proposition 4.2 the retailer i's best response stocking factor z_i^* that maximizes the retailer i's profit $\pi_{R_i}(P^*(z_i|w_p), z_i|w_p)$ for a given w_p is uniquely determined as the solution of:

$$\frac{z_i^*}{z_i^* - \Lambda(z_i^*)} + \frac{1}{\beta(c\alpha_i + w_p)} = \frac{1}{1 - F(z_i^*)} \quad (6)$$

Note that there is no closed form expression for z_i^*. However, we are able to prove the following property.

Corollary4.3. The best response stocking z_i is decreasing in w_p.

(6) can be rearranged as

$$\frac{1}{\beta(c\alpha_i + w_p)} = \frac{1}{1 - F(z_i^*)} - \frac{z_i^*}{z_i^* - \Lambda(z_i^*)}$$

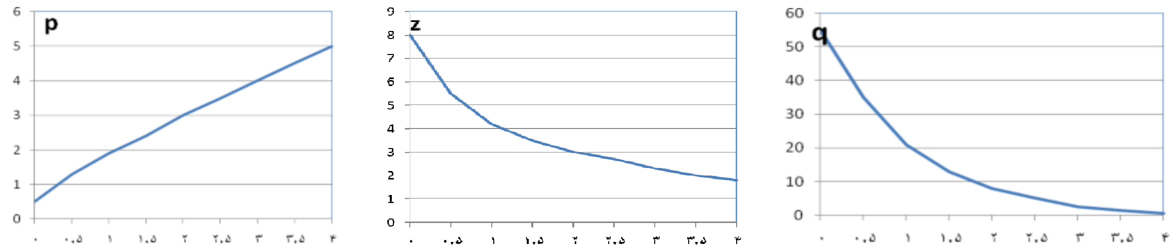
The right hand side is a decreasing function of w_p thus $\frac{1}{1 - F(z_i^*)} - \frac{z_i^*}{z_i^* - \Lambda(z_i^*)}$ decreasing in w_p.

This result means that as the supplier charges the retailer more per item, the retailer orders less compared with the expected demand to lower her overstock risk exposure.

Using (5) and (6), we obtain that the best response retail price to a wholesale price w_p is

$$p_i^*(z|w_p) = \frac{(c\alpha_i + w)z_i^*}{z_i^* - \Lambda(z_i^*)} + \frac{1}{\beta} + rG_1 \qquad (7)$$

Fig.1 illustrates the retailer's best response price, stocking factor and quantity as a function of supplier's wholesale price. The retailer's best response price increases with w_p. This observation is intuitive because as the supplier's wholesale price increasing, the retailer transfers this cost increase to consumers by increasing the retail price. The higher retail price causes the demand to go down, which leads to a lower quantity at each retailer. As a result, both the expected demand and quantity decrease with w_p. However, the order quantity decreases faster than the expected demand. Thus, the stocking factor decreases with the supplier's wholesale price (consistent with corollary 4.3)



Best response price p* **Best response stocking factor z*** **Best response quantity Q***

Fig1. Retailer 1's best response price, stocking factor and quantity as a function of the wholesale price wp when $\beta = 2$, $\gamma = 1{,}5$, $a = 10$, $\alpha_1 = \alpha_2 = .125$ $r = 1, G_1 = 10\%$ **in the PO contract**

4.1.2 Supplier's wholesale price decision

At the first step, anticipating the retailer's reaction, the supplier sets the wholesale price w_p to maximize her own expected profit:

$$\pi_s(w_p) = w_p(Q_1^* + Q_2^*) - c(1 - \alpha_1 - \alpha_2)(Q_1^* + Q_2^*) \qquad (8)$$

To find the equilibrium solution w_p^*, we seek to maximize $\pi_s(w_p)$ over w_p. Since z_i^* and p_i^* are only known as implicit functions of w_p given by (6) and (7), this problem has no analytical solution.

4.2 Consignment contracts

Consignment contract has been widely applied in various industries, such as rental and retailing and auction and procurement of industrial materials. Under such a contract, ownership of goods is retained by the supplier. For each item sold, supplier gets paid from the retailer on actual units sold. This policy may help to achieve Pareto improvement in a supply chain.

Our model is different from previous studies in that we consider consignment contract and consumer return policy with retail competition. Furthermore, we focus on retail-managed inventory, meaning that retailers decide the inventory quantity and chooses a retail price for selling the product to the market. This agreement is commonly used in supply chains

Under consignment contract, decisions are made in two sequential steps. At the first step, the supplier decides the w corresponding to the amount of payment to be received from the retailers for each unit sold to consumers. At the second step, given this w, each retailer simultaneously selects the retail price p_i and order quantity Q_i. We find the equilibrium solution by using backward induction. We first derive each retailer's best response price and inventory quantity to the supplier' consignment price decision.

4.2.1 Retailer i's selling price and stocking factor decision

The retailer i's problem is to determine the retail price p_i and order quantity Q_i appropriately so that her own expected profit is maximized. The retailer i's expected profit can be written

$$\pi_{R_i}(p_i, z_i|w) = y_i(p)\{\bar{G}_1[p_i - w][z_i - \Lambda(z_i)] - c\alpha_i z_i + G_1(p-r)(z_i - \Lambda(z_i))\} \quad (9)$$

To find the best response, denoted by (p_i^*, z_i^*) that maximizes $\pi_{R_i}(p_i, z_i|w)$ for a given w, we first derive the retailer's best response retail price $p_i^*(z_i|w)$ for a given stocking factor z_i, we then find the best response stocking factor z_i^* that maximizes $\pi_{R_i}(p_i^*(z_i|w), z_i|w)$. Note that z_i^* and p_i^* are functions of w but we omit to explicitly show the dependency to keep the notation simpler. The results are summarized in the following propositions.

Proposition4.4. For any given stocking factor z_i and w>0, price P_{-i} of retailer $-i's$, retailer $i's$ unique best response price $P_i^*(z_i|w)$ is given by

$$P_i^*(z_i|w) = rG_1 + \frac{1}{\beta} + \frac{c\alpha z_i}{z_i - \Lambda(z_i)} + w\bar{G}_1 \quad (10)$$

(10) Indicates that retailer's optimal price P_i^* consists of amount that the retailer has to pay to the supplier for each unit sold, and a mark-up for herself and expected returning cost per unit product.
Comparing the best repose retail price a consignment contract and a PO contract, we observe that for a fixed stocking z_i and a given supplier' price $w_p = w$ the PO best response retail is higher than best response retail price in a consignment price contract because $G_1 \prec \frac{z_i}{z_i - \Lambda(z_i)}$ This finding reflects the fact that in PO contract, the retailers incur more risk associated with returned products than in a consignment contract, and therefore charge consumers a higher retail price.
Proposition 4.4 implies that p_i depend on the supplier's price w.

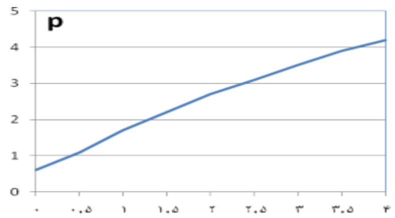
Proposition4.5. the retailer $i's$ best response stocking factor z_i^* that maximizes the retailer $i's$ profit $\pi_{R_i}(p_i(z_i^*|w), z_i|w)$ for a given w is uniquely determined as the solution of:

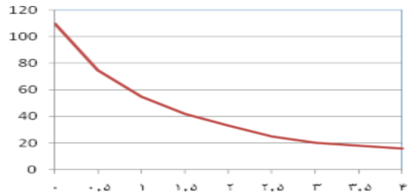
$$\frac{z_i^*}{z_i^* - \Lambda(z_i^*)} + \frac{1}{\beta c\alpha_i} = \frac{1}{1 - F(z_i^*)} \quad (11)$$

Proposition4.5. Implies that z_i^* does not depend on the supplier's price w rather it is uniquely determined by demand distribution and other system parameters and price w; thus z_i^* is the retailer $i's$ equilibrium stocking factor z_i.
Using (10) and (11), we find that the best response retail price to a price w is

$$P_i^*(z_i^*|w) = rG_1 + \frac{1}{\beta} + \frac{c\alpha z_i^*}{z_i^* - \Lambda(z_i^*)} + w\bar{G}_1 \quad (12)$$

From (11), the optimal z_i^*, chosen by the retailer i under consignment contract is the more from that chosen by retailer under price only contract as given in (6)
Fig.2 illustrates the retailers' best response price and quantity as a function of the price w. The best response retail price increases with w. Similarly to the PO contract, the retailers transfer any consignment price increase to consumers by increasing their retail prices, which causes the demand to decrease and thus the quantity to decrease.





Best response price p — Best response quantity Q

Fing2. Retailer 1's best response price and quantity as a function of the consignment price w when $\beta = 2, \gamma = 1{,}5, a = 10, \alpha_1 = \alpha_2 = .125\ r = 1\ G_1 = 10\%$ **in the consignment contract**

4.2.2 Supplier's consignment price decision

At the first step, anticipating the retailers' reaction to her decision, the supplier sets the consignment price w to maximize her own expected profit $\pi_s(w)$, given by

$$\pi_s(w) = \sum_{i=1}^{2} y_i(p)\{[w - c(1-\alpha_1-\alpha_2)]z_i - vG_1(z_1 - \Lambda(z_i))\} \quad (13)$$

To find the equilibrium solution, denoted by w, we maximize $\pi_s(w)$ over w.

Proposition4.6. the supplier's unique equilibrium consignment price w is given by

$$w = \frac{k_1[(z_1 - \Lambda(z_1)) + Fz_1] + k_2[(z_2 - \Lambda(z_2)) + Fz_2]}{(\beta-\gamma)G_1[k_1(z_1 - \Lambda(z_1)) + k_2(z_2 - \Lambda(z_2))]}$$

Where k_1, k_2, x_1 and x_2 as below

$$k_1 = e^{-\beta x_1 + \gamma x_2}$$

$$k_2 = e^{-\beta x_2 + \gamma x_1}$$

$$x_1 = \frac{c\alpha_1 z_1}{z_1 - \Lambda(z_1)}$$

$$x_1 = \frac{c\alpha_2 z_2}{z_2 - \Lambda(z_2)}$$

Proposition 4.7

The equilibrium stocking factor z^* decreases in β

The equilibrium supplier's consignment price w^* decreases in β

The equilibrium retail price p^* decreases in β

Proposition 4.7 indicates that the equilibrium stocking factor z^* decreases with the consumers' sensitivity to the retail price because $\frac{1}{c\alpha\beta}$ is a decreasing function in β. Since the expected demand decreases when consumers become more sensitive to the retail price, retailer reduces their order quantity to reduce the risk of excess inventory. Further, the consignment price w^* and the retail p^* are decreasing functions of β because $\frac{\partial w^*}{\partial \beta} \le 0$ and $\frac{\partial p^*}{\partial \beta} \le 0$: as consumers are more sensitive to the retail price, the supplier charges each retailer a lower consignment price so that retailers can lower their retail prices.

We now focus on the impact of retailer differentiation. Since the equilibrium stocking factor z_i^* is independent of the price cross-sensitivity, we study how the supplier's equilibrium consignment price w^*, the retailer's equilibrium selling price p_i^*, the retailer's equilibrium profit, the supplier's equilibrium profit and the total profit of the channel vary with the level of retailer differentiation.

Proposition 4.8

The supplier's consignment price at equilibrium w^* increases in γ

The retail price at equilibrium p^* increases in γ

The retailer's order at equilibrium Q^* increases in γ

The retailer's profit at equilibrium $\pi_R^{d^*}$ increases in γ

The supplier's profit at equilibrium $\pi_S^{d^*}$ increases in γ

Proposition 4.6 indicates that the supplier's consignment price increases in the price cross-sensitivity since $\frac{\partial w^*}{\partial \gamma} \geq 0$ This suggests that the supplier take advantage of increased competitiveness between less differentiated retailers (large γ) by charging higher consignment price. The retailer transfers this price increase to consumers by increasing their retail price $\frac{\partial p^*}{\partial \gamma} \geq 0$. This result is consistent with several existing studies. Furthermore, proposition 4.8 indicates that the quantity ordered by each retailer increases in γ. The effect of retail differentiation on the order quantity is subject to two opposing effects: a direct effect and an indirect effect though the retail price. On the other hand, as γ increases, the retail price increases which tend to make the expected demand decrease and thus would drive the quantity to go down. Because the direct effect is stronger, overall the order quantity increases when γ increases. Since supplier's consignment price, the retailers' selling price and the order quantity increase in γ, the profits for supplier and the retailers increase as the level of retailer differentiation decreases.

5. Conclusion

Consignment contracts have received increased attention in the recent supply chain management literature. Our study contributes to research consignment contracts and retail competition under return policy by providing insights on how the presences of retail competition and retailer differentiation affect the decisions and performance of supply chain. We observe that the PO best response retail price is higher than best response retail price in consignment also optimal z_i^* chosen by the retailer under consignment contract is the more from that chosen by retailer under PO contract. Retailer differentiation effects the decisions of the supplier and the retailers. With less retailer differentiation, the supplier increases the price the price. An increase of the supplier's price leads the retailers to increase the retail price. The order quantity in the consignment contract increases when the level of retailer differentiation decreases. The retailers earn a high profit when the level of retailer differentiation decreases in the consignment contract.

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