The Impact of RPM on Welfare Level under Competition between Supply Chains

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Abstract: - In Resale Price Maintenance (RPM) contracts, the manufacturer specifies the resale price that retailers must charge to consumers. The aim of the research is to investigate the role of using a RPM contract in a market where there are two competitive chains with demand uncertainty. We find that under the insignificant difference between high and low primary market demand and high degree of substitution between the two competitive products, after vertical integration of firms in every single chain adopting RPM strategy can enhance the social welfare level from disintegrated chain using the clearance pricing strategy.

Key-Words: Resale price maintenance; retail competition; the flexible pricing strategy; the optimal pricing strategy; welfare level; consumer surplus.

1 Introduction

In many industries, when manufacturers sell their products to independent retailer, they ask that retailers have to resale their products to consumers at specified prices. This phenomenon is referred to as RPM (resale price maintenance) in the practice. Just because manufacturers insist that the resale prices, which are set by retailers originally according to supply and demand, at a fixed level, it could damage the competition between retailers and could be a bad thing for consumers interest. Therefore, RPM has long been justified as necessary to limit such competition among retailers and has been the focus of legislative disputes as well as the discussion of numerous articles in professional journals.

In the essence of RPM game, the manufacturer first announces its wholesale price and the minimum retail price at which its product may be resold, and then retailers choose stock to hold, prior to the resolution of demand uncertainty. Once retailers inventories are in place, demand uncertainty is resolved. If the market-clearing price exceeds the minimum retail price, then the market-clearing price determines the price. Otherwise, the retail price is the minimum retail price announced by the manufacturer (Deneckere *et al*, 1997). Of course, the retailers have to burden the problem of unsold products in the RPM game. RPM always is beneficial to the manufacturers. But is it beneficial to the retailers? Gumani and Xi (2006) pointed out that one advantage of RPM is that it mitigates the double-marginalization problem in decentralized distribution system and can coordinate the channel when there is no retailer sales effort and demand is deterministic. The so-called double-marginalization means that if the supplier's (the manufacturer's) wholesale price is higher than its marginal cost, the buyer (the retailer) will order less than the optimal order quantity (Spengler, 1950).

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Therefore, if the double-marginalization exists, then it is impossible to reach the coordination in which the retailer orders the maximum quantity that maximizes the profit for the whole supply chain. Hence, the aggregate profit for the integrated supply chain in which the manufacturer and retailer are vertically integrated with each other to maximize the profit of supply chain is larger than that in the disintegrated supply chain in which the retailer and the manufacturer maximize its own profit, respectively.[1] RPM contract can be used as a way to solve the double-marginalization problem (Foros *et al*, 2009). Hence, RPM could be beneficial to the retailer, if the manufacturer can share the extra profit, made by the vertical integration, with the retailer when they are vertically integrated.

As noted above, if the market-clearing price exceeds the minimum retail price announced by the manufacturer, then the market-clearing price determines the price. Otherwise, the retail price is the minimum retail price. Hence, to compare the impact of RPM contract with that of the clearance pricing strategy on welfare is often made in the literature, and RPM can improve welfare in comparison to permitting prices to clear the market in the integrated supply chain (Flath and Nariu 2000, Fleshma and Willner 2005).

The explanation above makes it clear that the manufacturer does not like to make contract with the retailer to generate the double-marginalization problem, which implies that total profit is lower than in an integrated channel. Maybe the firms, no matter it is manufacturer or retailer, prefer the integrated supply to disintegrated supply chain. But, in the essence of RPM game, the manufacturer first announces its wholesale price to an independent retailer, and then the retailer makes its decisions in the following stages. So, we think that we have to be in the disintegrated supply chain at the initial state and then move to the integrated supply chain, if we want to investigate the impact of RPM on welfare. There are two pricing strategies that retailer can chooses in the disintegrated supply chain. One is the clearance pricing strategy and the other is the optimal pricing strategy. If there is sufficient difference between high and low demand, the retailer will find that it is a right decision to adopt the optimal pricing strategy. Otherwise, it adopts the clearance pricing strategy. Because we intent to investigate whether RPM can improve welfare in the integrated supply chain in comparison to permitting prices to clear the market in the disintegrated supply chain. Therefore, we assume that the difference between high and low is not sufficient for the retailer to adopt the optimal pricing strategy. That's, at initial state, the manufacture and retailer are in the disintegrated supply chain using the clearance pricing strategy. Subsequently, we discuss the case of the integrated supply chain in which retail price and stock level are ruled by manufacturer and manufacturer can choose RPM or flexible rice (just like the clearance pricing strategy) in the integrated supply chain. We demonstrate that manufacturer prefers RPM contract to the flexible price regime. Finally, we show that not only social welfare but also consumer surplus and producer surplus can be improved by RPM in the integrated supply chain in comparison to the clearance pricing strategy in the disintegrated channel. In order to keep the retailer engage in the clearance pricing strategy in the disintegrated supply chain and maintain the retail price under RPM contract is higher than that in the clearance pricing strategy in the low-demand state, we assume that the ratio of low-high primary demand is in a specified range, which implies the degree of substitution must be large. We show that the social welfare level is enhanced if firms are allowed to adopt RPM, even there exists the competition between supply chains.

The remainder of this paper is organized as follows. In section 2, we introduce the model characteristics under the two competitive supply chains which face the linear demand function with uncertainty and we set up the sequence of move for the following sections. In section 3 we first discuss the disintegrated supply chain, and assume that there are two pricing strategies, the clearance pricing strategy and the optimal pricing strategy, that the retailer can choose. Especially, we explain why the retailer chooses the clearance pricing strategy in the disintegrated supply chain. In section 4, we consider the integrated supply chain in which there are also two strategies for the firms to select. We demonstrate why the firms choose RPM contract. In section 5, we compare the impact of RPM contract

[1] Refer to Ding and Chen (2008), Zhou and Yang (2008) about the pricing strategy for coordination.

with that of the clearance pricing strategy on welfare. We make a conclusion in section 6.

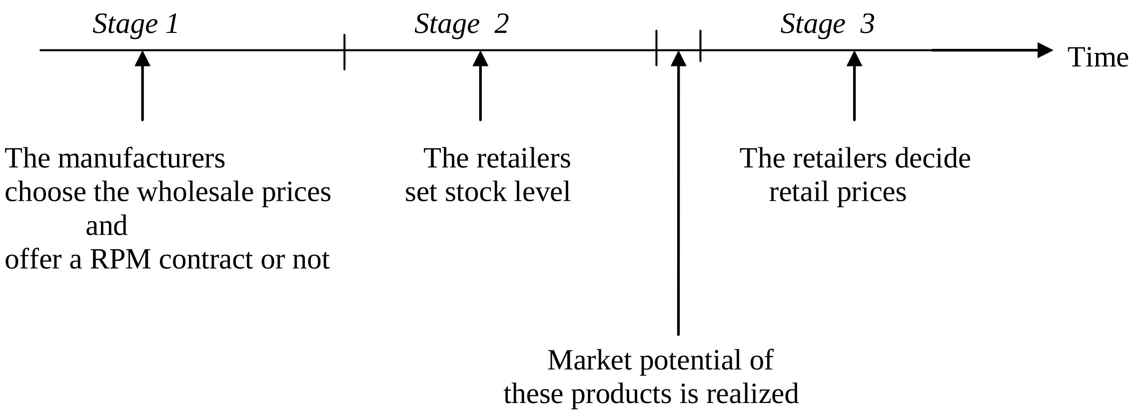

Figure 1 sequence of moves

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2 The Model

In the paper, we consider a model in which there are two supply chains. Each supply chain consists of a manufacturer and a retailer. In each supply chain, the manufacturer supplies its product to its retailer. Of course, the two supply chains that sell substitutable products are competitive. There are two kinds of supply chain structures, we discuss in this paper. They are

1. The Disintegrated Supply Chain

2. Integrated Supply Chain

The manufacturer and retailer maximize its own profit respectively in the disintegrated supply chain, and in the integrated supply chain the manufacturer and retailer vertically integrated with each other to maximize the profit for the whole supply chain.

In the disintegrated supply chain, Following Padmanabhan and Png (1997) and Ai *et al.* (2012), there are two pricing strategies that the retailers can adopt. One is the optimal pricing strategy and one is the clearance pricing strategy. In any pricing strategy, the retailer can be free to choose its stock level and retail price.

In the scenario of the clearance pricing strategy, the manufacturer initially announces a wholesale price, w. Retailers then choose how much stock level, *s*, to hold, prior to the resolution of demand uncertainty. The stock level maximizes its expected profit.With inventories in place, demand is realized. The retail price is determined according to supply and demand. That's, the retailers set the price to sell all stock. In literature the clearance pricing strategy is also called as the flexible price game (Deneckere *et al*. (1997), Flath, D. and T. Nariu (2005),In the scenario of the optimal pricing strategy, similarly, the manufacturer initially announces a wholesale price, w. And then retailers choose how much stock level to hold, prior to the resolution of demand uncertainty. But the stock level maximizes retailer profit in the high-demand state only and retailers determine the price to sell out its optimal stock. In the low-demand state retailer decide the price to maximize its profit, certainly, there exist some unsold products. For simplicity, we assume that manufacturing involves zero fixed cost and normalize production variable costs to zero, while the only cost of retailing is the payment of the wholesale price, w .The sequence of moves is illustrated in Figure 1.

In the integrated supply chain, the retail price and stock level are decided by the manufacturer. In the first stage, the manufacturers decide whether to offer a RPM contract. If the manufacturers offer a RPM contract (hereafter we call it RPM game), then in the second stage, the manufacturers produce the quantity, which maximizes the profit for the supply chain in the high-demand state, to its own supply chain to sell. In the third stage after the productions are in hands, the market potential is realized. If the market demand is high, the manufacturers set the retail prices to sell out all their productions. But if the market demand is low, the manufacturers will decide an optimal retail price to maximize the profit. Of course, some unsold productions will be left. If the manufactures do not offer the RPM contract in the first stage, then in the second stage the productions are planned to maximize the average expected profit. In the third stage the market demand is realized. Just like the clearance pricing strategy, the manufactures will set a retail price according to supply and demand to sell out production in each demand state. We call this scenario as the Flexible Price Regime.

The demand functions for the two retailers are:

$$\begin{cases} D_{e1} = a_e - p_{e1} + \gamma p_{e2} \text{ with probability } 1/2, \\ D_{e2} = a_e + \gamma p_{e1} - p_{e2} \text{ with probability } 1/2. \end{cases} \quad (1)$$

where subscript *e* means the demand state of the market. For example, *h* indicates the high-demand state and *l* the low-demand state. 1 and 2 mean supply chain 1 and 2, respectively. a_e represents the primary demand in state *e*. That's, a_h represents the high-demand state of the primary demand. Analogously, a_l represents the low-demand state of the primary demand. p represents the retail price, and γ represents the degree of substitution. Therefore, $0 \le \gamma \le 1$. The two products are wholly different and there is no competition between the two products when $\gamma = 0$. And if $\gamma = 1$, then the two products are identical in every respect of product character. We adopt the opinion of Deneckere *et al*. (1997), no matter the demand state is low or high, the probability that each state happens is the same. In other words, the probability is 1/2 for each state.

3 Competition in the Disintegrated Channels

Now, we pay our attention to the scenario of the clearance pricing strategy (denoted with a superscript *c*). Since the manufacturer is the leader and the retailer is the follower in the supply chain. According to Figure 1, the manufacturers choose the wholesale prices, w_i^c, in the first stage. Then, in the second stage the retailers set stock level, s_i^c. Retailers set stock level before they observe demand. With inventories in place, demand is realized. Hence, in the third stage, it'll set a price p_{hi}^c in the high-demand state, and a price p_{li}^c in the low-demand state to sell out its stock. According to the theory of game, we have to use a backward approach to analyse it.

3.1. The clearance pricing strategy

As mentioned above, in the third stage the market demand is certain, hence, retailers know what kind of demand stage happens in the market, it'll decide a price p_{hi}^c and p_{li}^c for each demand state to sell all s_i^c, respectively. That's,

$$p_{e1}^c = \frac{1}{1-\gamma^2}[(1+\gamma)a_e - s_1^c - \gamma s_2^c],$$

$$p_{e2}^c = \frac{1}{1-\gamma^2}[(1+\gamma)a_e - \gamma s_1^c - s_2^c]. \quad (2)$$

where *e*= *h*,.,

In the second stage, retailers will determine an optimal stock and retailers will sell it out. Therefore, the expected profit for retailer is

$$E[\pi_{Ri}^c] = \frac{1}{2}p_{hi}^c s_i^c + \frac{1}{2}p_{li}^c s_i^c - w_i^c s_i^c, i = 1,2. \quad (3)$$

where subscript *R* represents retailer, p_{hi}^C and p_{li}^C are determined by Eq. (2), respectively. . In the second stage, the retailer orders a stock to maximize its expected profit, prior to the resolution of demand uncertainty. Therefore, differentiating Eq. (3) with respect s_i^c to find the first-order condition, we discover that the profit maximizing stocking level, s_i^c, is

$$s_i^c = \frac{(1+\gamma)(2-\gamma)\overline{\alpha} - 2(1-\gamma^2)w_i^c + (1-\gamma^2)w_j^c}{4-\gamma^2},$$
$$i, j = 1,2, i \ne j. \quad (4)$$

where $\overline{a} = \alpha_h/2 + \alpha_l/2$.

Anticipating the retailer's stock and pricing strategy, the manufacturer's profit is

$$E[\pi_{Mi}^C] = w_i^c s_i^c. \quad (5)$$

Maximize Eq. (5) by choosing the optimal wholesale price. w_i^c. The equilibrium in the clearance pricing strategy, such as the wholesale and retail prices, stock level, and the firms' profits are listed in Table 1.

Table 1 Equilibrium in the clearance pricing strategy

Variable	Value
w_i^c	$\frac{(2-\gamma)\overline{\alpha}}{(4-\gamma)(1-\gamma)}$
s_i^c	$\frac{2(1+\gamma)\overline{\alpha}}{(4-\gamma)(2+\gamma)}$
p_{li}^c	$\frac{(2+\gamma)(4-\gamma)\alpha_l - 2\overline{\alpha}(1+\gamma)}{(1-\gamma)(2+\gamma)(4-\gamma)}$
p_{hi}^c	$\frac{(6-\gamma^2)\alpha_h + (1+\gamma)(\alpha_h-\alpha_l)}{(1-\gamma)(2+\gamma)(4-\gamma)}$
$E[\pi_{Ri}^c]$	$\frac{4(1+\gamma)\overline{\alpha}^2}{(1-\gamma)(2+\gamma)^2(4-\gamma)^2}$
$E[\pi_{Mi}^c]$	$\frac{2(2-\gamma)(1+\gamma)\overline{\alpha}^2}{(1-\gamma)(2+\gamma)(4-\gamma)^2}$

3.2. The optimal pricing strategy

Next, we examine the outcome in the optimal pricing strategy (denoted with a superscript *o*).

In the third stage, the market demand is resolved. Retailers know what kind of demand state happens in the market, but retailers just sell all its stock, s_1^o, s_2^o, ordered by retailer in the second stage, in the high-demand state, but not in the low-demand state. Therefore, the retail prices in the high-demand state are

$$p_{h1}^o = \frac{1}{1-\gamma^2}[(1+\gamma)a_h - s_1^o - \gamma s_2^o],$$

$$p_{h2}^o = \frac{1}{1-\gamma^2}[(1+\gamma)a_h - \gamma s_1^o - s_2^o]. \quad (6)$$

In this scenario, the profit for retailer is

$$E[\pi_{Ri}^o] = \frac{1}{2}p_{hi}^o s_i^o + \frac{1}{2}p_{li}^o(\alpha_l - p_{li}^o + \gamma p_{lj}^o) - w_i^o s_i^o, \quad i = 1,2. \quad (7)$$

We have shown that, if demand is high, the retailer will price to sell all the stock. Hence, the retail prices in the high-demand state are decided by Eq. (12). When retailer learn that the demand is low (*i.e.*, $\alpha = a_l$), retailers will choose an optimal price to maximize its profit in the low-demand state. That's,

$$p_{l1}^o = p_{l2}^o = \frac{\alpha_l}{2-\gamma}. \quad (8)$$

Putting Eq. (8) into Eq. (7), the profit for retailers can be rewritten as follows:

$$E[\pi_{Ri}^o] = \frac{1}{2}p_{hi}^o s_i^o + \frac{\alpha_l^2}{2(2-\gamma)^2} - w_i^o s_i^o, \quad i = 1,2. \quad (9)$$

In the second stage, retailers choose an optimal stock level to maximize its profit in the high-demand state, prior to the resolution of demand uncertainty. If there is sufficient difference between high and low demand, the retailer will find it optimal to order a stock level, s_i^o, such that he will stock out if demand is high and hold excess inventory if demand is low. For the retailer's profit in Eq. (15), the profit maximizing stock level is

$$s_i^o = \frac{1}{4-\gamma^2}[(2-\gamma)(1+\gamma)\alpha_h - 4(1-\gamma^2)w_i^o + 2\gamma(1-\gamma^2)w_j^o]. \quad (10)$$

Table 2 Equilibrium in the optimal pricing strategy

Variable	Value
w_i^o	$\frac{(2-\gamma)\alpha_h}{2(4-\gamma)(1-\gamma)}$
s_i^o	$\frac{2\alpha_h(1+\gamma)}{(4-\gamma)(2+\gamma)}$
p_{li}^o	$\frac{\alpha_l}{2-\gamma}$
p_{hi}^o	$\frac{(6-\gamma^2)\alpha_h}{(1-\gamma)(2+\gamma)(4-\gamma)}$
$E[\pi_{Ri}^o]$	$\frac{2(1+\gamma)\alpha_h^2}{(1-\gamma)(2+\gamma)^2(4-\gamma)^2} + \frac{\alpha_l^2}{2(2-\gamma)^2}$
$E[\pi_{Mi}^o]$	$\frac{(2-\gamma)(1+\gamma)\alpha_h^2}{(1-\gamma)(2+\gamma)(4-\gamma)^2}$

The manufacturer's profit is the same as Eq. (5). Of course, w_i^c is replaced by w_i^o and s_i^c is replaced by s_i^o in Eq. (5). Maximize $E[\pi_{Mi}^o]$ by choosing the optimal wholesale price. w_i^o. The equilibrium in the clearance pricing strategy, such as the wholesale and retail prices, stock level, and the firms' profits are listed in Table 2.

3.3 Discussion

From Table 1 and 2, we derive

$$s_i^c - s_i^o = \frac{-(1+\gamma)(\alpha_\mathrm{h} - \alpha_l)}{(4-\gamma)(2+\gamma)} < 0 .$$

No matter how much the difference between high demand (α_h) and low demand (a_l), and no matter how much the degree of substitution (γ) is, the wholesale price in the optimal pricing strategy is always bigger than that in the clearance pricing strategy. So, from the standpoint of stock level, manufacturer is better under the optimal pricing strategy. But since

$$w_i^c - w_i^o = \frac{(2-\gamma)\alpha_l}{2(4-\gamma)(1-\gamma)} > 0 .$$

Hence, from the standpoint of wholesale price, manufacturer is better under the clearance pricing strategy. Hence, we are not sure that if the clearance pricing strategy or the optimal pricing strategy is better for the manufacturers. The result happens to the retailers similarly. Therefore, we need to further investigate.

From Table 1 and 2, we derive

$$E[\pi_{Mi}^o] - E[\pi_{Mi}^c] = \frac{(1+\gamma)(2-\gamma)[\alpha_h^2 - 2\alpha_h\alpha_l - \alpha_l^2]}{(1-\gamma)(2+\gamma)(4-\gamma)^2} .$$

Therefore,

$E[\pi_{Mi}^o] > E[\pi_{Mi}^c]$, If $\alpha_h / \alpha_l > 2.414$,

$E[\pi_{Mi}^o] < E[\pi_{Mi}^c]$, if $1 < \alpha_h / \alpha_l < 2.414$.

$$E[\pi_R^c] - E[\pi_R^o] = \frac{2(1+\gamma)(2-\gamma)^2[(1-A\alpha_l^2 + 2\alpha_l\alpha_h - \alpha_h^2]}{2(1-\gamma)(2+\gamma)^2(4-\gamma)^2},$$

where $A \equiv (1-\gamma)(2+\gamma)^2(4-\gamma^2)/2(1+\gamma)(2-\gamma)^2$. A is positive for every $\gamma \in [0,1]$. And no matter $1-A$ is positive or negative, we obtain the following conditions:

$E[\pi_R^c] > E[\pi_R^o]$, if $\alpha_h^2 - 2\alpha_l\alpha_h - (1-A)\alpha_l^2 < 0$,

$E[\pi_R^c] < E[\pi_R^o]$, if $\alpha_h^2 - 2\alpha_l\alpha_h - (1-A)\alpha_l^2 > 0$.

If $\alpha_h^2 - 2\alpha_l\alpha_h - (1-A)\alpha_l^2 < 0$, then,

$$1 < \frac{\alpha_h}{\alpha_l} < 1 + \sqrt{2-A} \Rightarrow E[\pi_R^c] > E[\pi_R^o].$$

In other words, if $1 < \alpha_h / \alpha_l < 1 + \sqrt{2-A}$, the retailer prefers the clearance pricing strategy to the optimal pricing strategy. Contrarily, if $\alpha_h^2 - 2\alpha_l\alpha_h - (1-A)\alpha_l^2 > 0$, that's, if $\alpha_h / \alpha_l > 1 + \sqrt{2-A}$, then the retailer prefers the optimal pricing strategy to the clearance pricing strategy. Since $A > 0$, hence $1 + \sqrt{2-A} < 1 + \sqrt{2} = 2.414$. It is illustrated in Figure 2 in which shows that the area that the manufacturers and the retailers prefer the clearance pricing strategy to the optimal pricing strategy.

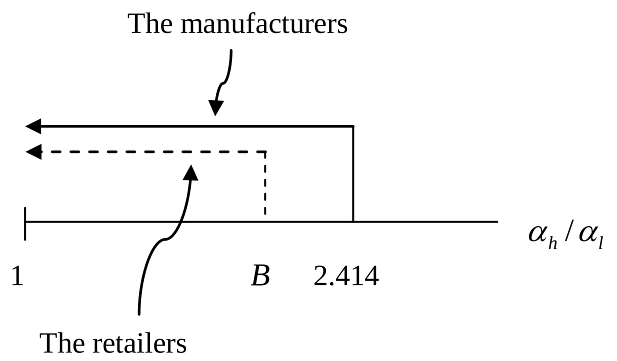


Figure 2 the area in which firms choose c strategy

Note 1： $B = 1 + \sqrt{2-A} < 2.414$

Note 2：c strategy means the clearance pricing strategy

Figure 2 illustrates that both retailers and manufacturers profit more from the retailers' optimal pricing strategy if $\alpha_h / \alpha_l > 2.414$, and if $B \le \alpha_h / \alpha_l \le 2.414$, retailers profit more under the retailers' optimal pricing strategy, while manufacturers profit more under the retailers' clearance pricing strategy, but both retailers and manufacturers prefer the clearance pricing strategy to the optimal pricing strategy if $\alpha_h / \alpha_l < B$.

That's, if there is sufficient difference between high and low demand, the firm (no matter it is the manufacturer or the retailer) will find that it is a right decision to adopt the optimal pricing strategy between the two pricing strategies. But if the difference between high and low demand is insignificant, then, the clearance is better than the optimal pricing strategy for the firm. Padmanabhan and Png (1997) pointed out that the independent retailer is always better off under the optimal pricing strategy in the disintegrated supply chain in which there are only one retailer and one manufacturer. From Figure 2, we found that the threshold, which induces the firm to accept the optimal pricing strategy from the clearance pricing strategy, for the retailer is lower than that for the manufacturer in the market in which there are two disintegrated supply chains. In other words, the retailer is easier to accept the optimal pricing strategy than the manufacturer in the market where exists the competition between two disintegrated supply chains. And from the above analysis, we know that A decreases and B increases as $\gamma \to 1$ .when γ approaches 1, then the range of $(1, B)$ will be narrower.

We assume that $\alpha_h / \alpha_l \in (1, B)$. That's, at the initial state, the retailers adopt the clearance pricing strategy. , and the equilibria are list in the Table 1.

4 Competition in the Integrated Channels

Now, we consider the environment in which the retailer is vertically integrated with the manufacturer in each supply chain to make the supply chain to be as the integrated one. There are also two cases to be considered, one is the RPM game(denoted with a superscript *RPM*) and one is the flexible price regime(denoted with a superscript *FLE*). In the integrated supply chain, the retail price and stock level both are decided by the manufacturer. Just like the previous section, the market demand is uncertain when the manufacturers choose their productions in second stage, but the manufacturers learn that the market demand is high or low when they set retail prices in the third stage.

4.1. The RPM Game

Similarly, we have to use a backward approach to analyse it. In the third stage of the RPM game, the manufacturers will set the retail price to sell out all their productions if the market demand is high. Therefore, the retail price in the high-demand state is

$$P_{hi}^{RPM} = \frac{1}{1-\gamma^2}[(1+\gamma)a_h - (1+\gamma)S_i^{RPM}], \quad (11)$$

where capital P represents the retail price and capital S represents the stock level/production in the integrated supply chain, and superscript *RPM* indicates the RPM game.

The expected profit for the supply chain is

$$E[\Pi_i^{RPM}] = \frac{1}{2}P_{hi}^{RPM}S_i^{RPM} + \frac{1}{2}P_{li}^{RPM}X_i^{RPM}, \quad (12)$$

where $X_i^{RPM} (= \alpha_l - P_{li}^{RPM} + \gamma P_{lj}^{RPM})$ is the sales in the low-demand state. Maximizing Eq. (12) with respect to P_{li}^{RPM}, we find

$$P_{li}^{RPM} = \frac{\alpha_l}{2-\gamma}, \quad (13)$$

and $$X_i^{RPM} = \frac{\alpha_l}{2-\gamma}. \quad (14)$$

Looking forward from the second stage by putting Eq. (13) and (14) into Eq. (12), the expected profit for the supply chain is

$$E[\Pi_i^{RPM}] = \frac{1}{2}P_{hi}^{RPM}S_i^{RPM} + \frac{1}{2}(\frac{\alpha_l}{2-\gamma})^2.$$

The profit maximizing stocking level, S_i^{RPM}, is

$$S_i^{RPM} = \frac{(1+\gamma)\alpha_h}{2+\gamma}.$$

Table 3 Equilibrium in the RPM game

Variable	Value
S_i^{RPM}	$\frac{(1+\gamma)\alpha_h}{2+\gamma}$
X_i^{RPM}	$\frac{\alpha_l}{2-\gamma}$
P_{li}^{RPM}	$\frac{\alpha_l}{2-\gamma}$
P_{hi}^{RPM}	$\frac{\alpha_h}{(1-\gamma)(2+\gamma)}$
$E[\Pi_i^{RPM}]$	$\frac{(1+\gamma)\alpha_h^2}{2(1-\gamma)(2+\gamma)^2} + \frac{\alpha_l^2}{2(2-\gamma)^2}$

The retail price, stocking level/sales and the profit of supply chain are reported in Table 3.

4.2. The Flexible Price Regime

Next, we discuss the case of the flexible price regime in which the manufacturer sets the retail prices to sell out all their productions, so the retail prices are

$$P_{hi}^{FLE} = \frac{1}{1-\gamma^2}[(1+\gamma)a_h - S_i^{FLE} - \gamma S_j^{FLE}],$$
$$P_{li}^{FLE} = \frac{1}{1-\gamma^2}[(1+\gamma)a_l - S_i^{FLE} - \gamma S_j^{FLE}]. \quad (15)$$

Looking forward from the second stage, the expected profit for the supply chain is

$$E[\Pi_i^{FLE}] = \frac{1}{2}P_{hi}^{FLE}S_i^{FLE} + \frac{1}{2}P_{li}^{FLE}S_i^{FLE}, \quad (16)$$

where P_{hi}^{FLE} and P_{li}^{FLE} are defined in Eq. (15. Maximizing Eq. (16) with respect to S_j^{FLE} by means of Eq. (15), and solving the first-order condition, we determine

$$S_i^{FLE} = \frac{(1+\gamma)\overline{\alpha}}{(2+\gamma)}.$$

Similarly, we list the results for the scenario in Table 4.

Table 4 Equilibrium in the Flexible Price Regime

Variable	Value
S_i^{FLE}	$\frac{(1+\gamma)\overline{\alpha}}{(2+\gamma)}$
P_{li}^{FLE}	$\frac{(3+\gamma)\alpha_l - (1+\gamma)\alpha_h}{2(1-\gamma)(2+\gamma)}$
P_{hi}^{FLE}	$\frac{(3+\gamma)\alpha_h - (1+\gamma)\alpha_l}{2(1-\gamma)(2+\gamma)}$
$E[\Pi_i^{FLE}]$	$\frac{(1+\gamma)\overline{\alpha}^2}{(1-\gamma)(2+\gamma)^2}$

4.3 Discussion

From Table 3 and 4, we derive

$$E[\Pi_i^{RPM}] - E[\Pi_i^{FLE}]$$
$$= \frac{1}{4(1-\gamma)(2+\gamma)^2}[(1+\gamma)(\alpha_h - \alpha_l)^2] + \frac{(1+3\gamma)(2-\gamma)^2\alpha_h^2 - 4\gamma^3\alpha_l^2}{4(1-\gamma)(2+\gamma)^2(2-\gamma)^2}. \quad (17)$$

Since

$$\frac{1}{4(1-\gamma)(2+\gamma)^2}[(1+\gamma)(\alpha_h - \alpha_l)^2] > 0,$$

so, the only thing left to be checked is the sigh of the second term in Eq. (17) in order to decide the sigh of Eq. (17).

After simple calculation, we , we can obtain

$$(1+3\gamma)(2-\gamma)^2\alpha_h^2 - 4\gamma^3\alpha_l^2$$
$$= (4+8\gamma-11\gamma^2-\gamma^3)\alpha_h^2 + 4\gamma^3(\alpha_h^2 - \alpha_l^2).$$

In the above equation, $4\gamma^3(\alpha_h^2 - \alpha_l^2) > 0$ due to $\alpha_h - \alpha_l > 0$, and $(4+8\gamma-11\gamma^2-\gamma^3) > 0$ for any $\gamma \in [0,1]$. That's,

$$\frac{(1+3\gamma)(2-\gamma)^2\alpha_h^2 - 4\gamma^3\alpha_l^2}{4(1-\gamma)(2+\gamma)^2(2-\gamma)^2} > 0.$$

In other words, $E[\Pi_i^{RPM}] > E[\Pi_i^{FLE}]$.

Therefore, if the manufacturer and retailer are vertically integrated with each other, then they prefer the RPM strategy to the flexible price strategy.

5 Welfare Effects

The main focus of this article is on the welfare effects between the occurrence of resale price maintenance in the integrated channel versus the clearance pricing strategy in the disintegrated channel. Following the convention in the literature, we define welfare (W) as the sum of consumer surplus (CS) and aggregate profit (Π):

$$W = CS + \Pi. \quad (18)$$

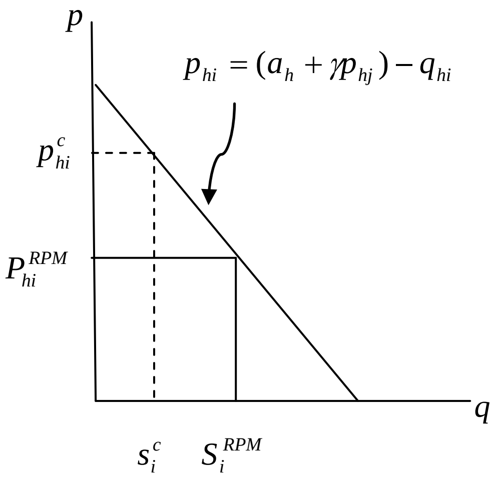
First, we want to discuss the change of consumer surplus from the disintegrated supply chain using the clearance pricing strategy to the integrated supply chain using the RPM contract.

The most important consideration in welfare effects are the price and quantity differences. Hence now, we want to compare the prices and the stock/production between the clearance pricing strategy in the disintegrated channel and the RPM contract in the integrated channel. From Table 1 and 3, we can derive

$$p_{hi}^c - P_{hi}^{RPM} = \frac{(1+\gamma)(2-\gamma)\alpha_h + 2(1+\gamma)\overline{\alpha}}{(1-\gamma)(2+\gamma)(4-\gamma)} > 0,$$

$$S_i^{RPM} - s_i^c = \frac{(1+\gamma)[(3-\gamma)\alpha_h - \alpha_l]}{(4-\gamma)(2+\gamma)} > 0.$$

In the high-demand state, the stock/production is larger and the price is lower in the integrated channel using RPM than those in the disintegrated channel using the clearance pricing strategy. The result is illustrated in the following diagram.



The gain of consumer surplus in the high-demand state is

$$\frac{1}{2}(S_i^{RPM} + s_i^c)\,(p_{hi}^c - P_{hi}^{RPM})$$
$$= \frac{(1+\gamma)^2[(5-\gamma)\alpha_h + \alpha_l][(3-\gamma)\alpha_h + \alpha_l]}{2(1-\gamma)(4-\gamma)^2(2+\gamma)^2} \quad (19)$$

And in the low-demand state,

$$P_{li}^{RPM} - p_{li}^c = \frac{(2-\gamma)(1+\gamma)\alpha_h - (6+\gamma)\alpha_l}{(1-\gamma)(2+\gamma)(4-\gamma)(2-\gamma)},$$

$$s_i^c + X_i^{RPM} = \frac{(1+\gamma)(2-\gamma)\alpha_h - (6+\gamma)\alpha_l}{(4-\gamma)(2+\gamma)(2-\gamma)}.$$

We need the following assumption in order to decide the signs of $P_{li}^{RPM} - p_{li}^c$ and $s^c - X^{RPM}$.

[**Assumption 1**]

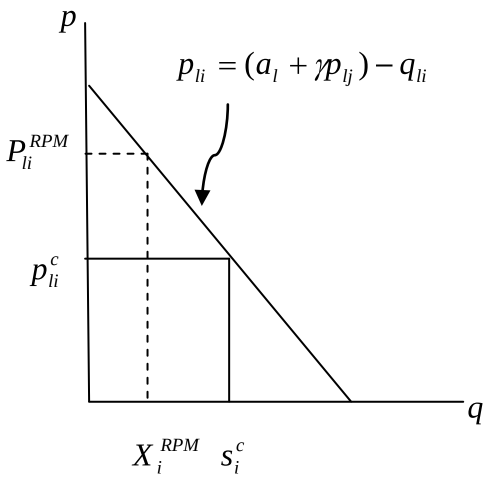
$\alpha_h / \alpha_l > (6+\gamma)/(1+\gamma)(2-\gamma)$.

As mentioned above, at the initial state, each retailer adopts the clearance pricing strategy in the disintegrated channel. That's, $\alpha_h / \alpha_l \in (1, B)$. And now, including assumption 1, we need that $(6+\gamma)/(1+\gamma)(2-\gamma) < \alpha_h / \alpha_l < B$.

According to assumption 1, we obtain

$P_{li}^{RPM} > p_{li}^c$, ; $s_i^c > X_i^{RPM}$.

That's, in the low-demand state, the price is higher and the stock/production is smaller in the integrated channel using RPM than those in the disintegrated channel using the clearance pricing strategy.



The loss of consumer surplus in the low-demand state is

$$\frac{1}{2}(s_i^c + X_i^{RPM})\,(P_{li}^{RPM} - p_{li}^c)$$
$$= \frac{(1+\gamma)^2[(2-\gamma)\alpha_h + (5-2\gamma)\alpha_l][(2-\gamma)\alpha_h - \alpha_l]}{2(1-\gamma)(4-\gamma)^2(2+\gamma)^2(2-\gamma)^2}$$
$$- \frac{5\alpha_l[(1+\gamma)[(2-\gamma)\alpha_h + (6-2\gamma)\alpha_l + 5\alpha_l]}{2(1-\gamma)(4-\gamma)^2(2+\gamma)^2(2-\gamma)^2}. \quad (20)$$

ΔCS (the change of consumer surplus) =
Eq. (19) – Eq. (20)

$$= \frac{E\alpha_h^2 + F\alpha_h\alpha_l + G\alpha_l^2}{2(1-\gamma)(4-\gamma)^2(2+\gamma)^2}$$

where

$$E = (2-\gamma)^2(14 - 8\gamma + \gamma^2) > 0$$
$$F = (1+\gamma)(2-\gamma)(17 + 2\gamma - 8\gamma^2 + 2\gamma^3) > 0$$
$$G = \{(1+\gamma)^2(9 - 5\gamma + \gamma^2) + 5[(1+\gamma)(6-2\gamma) + 5]\} > 0.$$

That's, $\Delta CS > 0$.

Next, we want to show the change of the aggregate profit in the disintegrated channel using the clearance pricing strategy and that in the integrated channel using RPM contract. In the former case the aggregate profit is

$$\frac{1}{2}E[\pi_{Ri}^{c}]+\frac{1}{2}E[\pi_{Mi}^{c}]=\frac{(1+\gamma)(6-\gamma^{2})\overline{\alpha}^{2}}{(1-\gamma)(2+\gamma)^{2}(4-\gamma)^{2}}.$$

Therefore, the change of aggregate profit, $\Delta\Pi$, is

$$E[\Pi_{i}^{RPM}]-(\frac{1}{2}E[\pi_{Ri}^{c}]+\frac{1}{2}E[\pi_{Mi}^{c}])=\frac{(1+\gamma)(2-\gamma)^{2}(\alpha_{h}-\alpha_{l})^{2}+C}{(1-\gamma)(2+\gamma)^{2}(4-\gamma)^{2}}+\frac{(1+\gamma)(10-8\gamma+2\gamma^{2})\overline{\alpha}^{2}}{(1-\gamma)(2+\gamma)^{2}(4-\gamma)^{2}}.$$

where

$$C=(4+8\gamma-11\gamma^{2}-\gamma^{3})\alpha_{h}^{2}+4\gamma^{3}(\alpha_{h}^{2}-\alpha_{l}^{2}).$$

Since

$$C=(4+8\gamma-11\gamma^{2}-\gamma^{3})\alpha_{h}^{2}+4\gamma^{3}(\alpha_{h}^{2}-\alpha_{l}^{2})>0$$

for every $\gamma\in[0,1]$. That's,

$$E[\Pi_{i}^{RPM}]>\frac{1}{2}(E[\pi_{Ri}^{c}]+E[\pi_{Mi}^{c}]),$$

or

$$\Delta\Pi>0.$$

In other words, the manufacturers and retailers have incentive to be vertically integrated with each other. They'd be better off from the disintegrated channel adopting the clearance pricing strategy to the integrated channel adopting the RPM contract.

From Eq. (18), we derive

$$\Delta W=\Delta CS+\Delta\Pi.$$

Since $\Delta CS>0$ and $\Delta\Pi>0$, therefore, $\Delta W>0$.

Even there exists the competition between two supply chains, it can be shown that the social welfare level is enhanced if firms are allowed to adopt RPM.

6 Conclusion

Of course, it is more complicated to discuss the impact of RPM on welfare level in the scenario in which there are two competitive supply chains. But it could be not adequate to investigate whether the impact of RPM can improve welfare level in comparison to the flexible price regime (or the clearance pricing strategy) in the case in which there is just only one integrated supply chain. After all, in the essence of RPM, the retail pricing and stock both are dominated by the manufacturer. Hence just like the articles in the literature, we consider the impact of RPM on welfare in the integrated supply chains in comparison to the clearance pricing strategy in the disintegrated supply chains with retail competition.

In order to maintain the retailer to adopt the clearance pricing strategy in the disintegrated supply chain at initial state. We assume that there is no sufficient difference between low and high demand for the retailer to adopt the optimal pricing strategy. After the vertical integration is established, we find that the firms prefer RPM to the flexible price regime.

RPM may lead to higher or lower retail prices compared to the clearance pricing strategy chosen by the retailer. In the high-demand state, the retail price under RPM is lower than that in the clearance pricing strategy due to vertical integration. But in order to keep the existence of phenomenon, which RPM is often criticized, that the firm is committed in a smaller quantity of trade and a higher retail price in the low-demand state. Hence, we make the assumption that the ratio of the low and high primary demand must belong to a specified range, which implies that the degree of substitution of the two competitive products must be large. We find that under the insignificant difference between high and low primary market demand and high degree of substitution between the two competitive products, after vertical integration of firms in every single chain adopting RPM strategy can enhance the social welfare level from disintegrated chain using the clearance pricing strategy, even there exists two competitive chains.

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