POMS PRODUCTION AND OPERATIONS MANAGEMENT

PRODUCTION AND OPERATIONS MANAGEMENT POMS

Vol. 26, No. 11, November 2017, pp. 2122–2136
ISSN 1059-1478 | EISSN 1937-5956 | 17 | 2611 | 2122

DOI 10.1111/poms.12749

Manufacturer Rebate Competition in a Supply Chain with a Common Retailer

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We consider manufacturer rebate competition in a supply chain with two competing manufacturers selling to a common retailer. We fully characterize the manufacturers' equilibrium rebate decisions and show how they depend on parameters such as the fixed cost of a rebate program, market size, the redemption rate of rebate, the proportion of rebate-sensitive consumers in the market and competition intensity. Interestingly, more intense competition induces a manufacturer to lower rebate value or stop offering rebate entirely. Without rebate, it is known that more intense competition hurts the manufacturers and benefits the retailer. With rebate, however, more intense competition could benefit the manufacturers and hurt the retailer. We find similar counterintuitive results when there is a change in some other parameters. We also consider the case when the retailer subsidizes the manufacturers sequentially to offer rebate programs. We fully characterize the retailer's optimal subsidy strategy, and show that subsidy always benefits the retailer but may benefit or hurt the manufacturers. When the retailer wants to induce both manufacturers to offer rebate, he always prefers to subsidize the manufacturer with a higher fixed cost first. Sometimes the other manufacturer will then voluntarily offer rebate even without subsidy.

Key words: supply chain management; rebate; manufacturer competition; incentive
History: Received: January 2016; Accepted: June 2017 by M. Eric Johnson, after 2 revisions.

1. Introduction

Rebate is a very popular type of sales promotion. More than $8 billion worth of rebates were issued to American households in 2010 (PR Newswire 2011b). According to a survey of UK shopper behavior (Parago 2014), about three out of four shoppers want cash back rebates on appliances and electronics and one out of three shoppers are interested in rebates on consumer packaged goods. An industrial study shows that 50% of retailers and 48% of manufacturers use rebates as part of their customer loyalty and promotions mix (PR Newswire 2011a). Firms use rebates for various purposes, such as demand expansion, price discrimination across different consumer segments, or moving inventory. Competing manufacturers often offer rebates to the same consumer market. For example, Unilever and P&G, two major competitors in the fast moving consumer goods industry, frequently offer mail-in rebates to consumers. Canon and Epson, two major manufacturers in the electronics industry, distribute competing products such as printers through retailers like Staples and offer mail-in rebates for a valid purchase. However, not all the manufacturers in the same industry offer rebates. For example, in the computer industry, Dell and HP are phasing out their rebate programs whereas other manufacturers such as Samsung and Sony continue to offer rebates (Darlin 2006). A common feature of these rebate programs is that consumers have to redeem rebate via mail or the Internet, and as a result, the redemption rate is usually less than 100%.

Because retailers could benefit from a higher demand due to manufacturers' rebate programs, they have an incentive to subsidize these programs. Many retailers, such as Walmart and Staples, invest resources to promote these programs in their stores as well as on their websites. Some retailers support manufacturer rebate programs in the form of sharing the fixed cost, and they do so for some, but not all, of the manufacturers in the same product category. For instance, Staples sets up an online system to process manufacturer rebates on behalf of Epson but not Canon, even though it sells the printers made by both manufacturers. Newegg.com partners with MSI to offer exclusive mail-in rebates, but no such arrangement is made for Asus even though both sell video cards through Newegg.com. Kohl's works with Philips but not Panasonic to offer exclusive mail-in rebates, even though both sell their products through Kohl's.

The impact of manufacturer rebate on supply chain management has been studied in the literature. Most of the papers examine a one-manufacturer-one-retailer relationship. The only exception is Demirag et al. (2011), which considers two competing supply chains with instant rebate (i.e., redemption rate is 100%). As described earlier, it is not uncommon for competing manufacturers to have different strategies in offering mail-in rebate programs (with less than 100% redemption rate) when they sell through a common retailer. It is also not uncommon for a retailer to selectively subsidize only some, but not all, of the competing manufacturers selling through its channel. Because the existing theory cannot explain these phenomena, we hope to fill this gap by specifically addressing the following research questions. What is the incentive for manufacturers to offer rebate when they sell substitutable products through a common retailer? How should a retailer subsidize these manufacturers to offer rebate? How do the answers to these questions depend on factors such as competition intensity, fixed cost of a rebate program, redemption rate of rebate and the proportion of rebate-sensitive consumers in the market?

We consider a model with two competing manufacturers selling substitutable products through a common retailer. A consumer incurs a cost in redeeming rebate, which can be high or low, and makes purchasing decision based on his estimated redemption cost. A consumer with a low redemption cost always estimates his cost correctly, but a consumer with a high redemption cost underestimates his cost to be low with a positive probability. When cost underestimation occurs, a consumer may be sensitive to rebate (i.e., account for the rebate value) at the time when purchasing decision is made but does not redeem it afterwards, which is called the slippage effect. In the base model, we assume that the low redemption cost is zero and the high redemption cost is very high such that it prohibits a consumer from redeeming rebate. This gives rise to two consumer segments with consumers who are respectively rebate-sensitive (the estimated redemption cost is zero) and rebate-insensitive (the estimated redemption cost is infinitely high). Rebate allows a manufacturer to increase demand from the rebate-sensitive market segment and, with the slippage effect, its actual redemption rate is lower than 100%. In our model, the manufacturers first decide whether or not to offer a rebate program with the associated fixed cost. Then they compete by determining the wholesale prices and rebate values (if a rebate program is in place). Finally, the common retailer determines the retail prices for both products. We consider two cases depending on whether or not the retailer can subsidize the manufacturers' rebate programs.

First consider the case when the retailer cannot subsidize rebate programs. Without competition, a manufacturer offers rebate if the fixed cost of a rebate program is low, market size is large, rebate redemption rate is low, or the proportion of rebate-sensitive consumers is large. With competition, both manufacturers offer rebate when their fixed costs are low, and none of them offers rebate when their fixed costs are high. Otherwise the manufacturer with a low fixed cost offers rebate whereas the one with a high fixed cost does not. When competition is less intense, it is more likely for the manufacturers to offer rebate. The effect of other parameters is similar to the case of no competition.

As mentioned in the report on the analysis of loyalty discounts and rebates under unilateral conduct laws (International Competition Network 2009), loyalty discounts and rebates are considered a legitimate form of price competition and generally pro-competitive. One would expect that more intense competition induces a manufacturer to raise rebate value to increase market share. However, our analysis shows that this conjecture is not necessarily correct. When competition is more intense, a manufacturer lowers her rebate value or stops offering rebate entirely. This is because she has to lower wholesale price, which leads to a lower profit margin and limits her ability in offering a higher rebate value.

Without rebate, more intense competition hurts the manufacturers and benefits the retailer, whereas a smaller market size generally hurts all the firms. With rebate, however, when more intense competition or a smaller market size induces a manufacturer to cease offering rebate, it hurts the retailer, benefits a non-rebate-offering rival manufacturer, and benefits a rebate-offering rival manufacturer if competition is intense and hurts her otherwise. Without competition, a manufacturer who offers rebate program is usually hurt when redemption rate becomes higher or the rebate-sensitive segment becomes smaller. With competition, however, she could benefit if competition is intense and either of these two changes triggers the rival manufacturer to stop offering rebate. We also show that when a manufacturer stops offering rebate due to a higher fixed cost, it hurts a rebate-offering rival manufacturer if competition is not intense and benefits her otherwise. These results can be explained as follows. The retailer is worse off with fewer rebate programs because rebate is a cost effective way to stimulate demand. Suppose the rival manufacturer stops offering rebate and consequently lowers her wholesale price. A non-rebate-offering manufacturer is better off because the rival manufacturer now loses some pricing flexibility. For a rebate-offering manufacturer, she responds by lowering the wholesale price and adjusts her rebate to raise the net retail price in the rebate-sensitive segment. This intensifies competition in the rebate-insensitive segment and softens it in the rebate-sensitive segment. If competition is more intense, the manufacturers compete more fiercely in the rebate-sensitive segment when both offer rebate, and therefore the positive effect of softening competition in the rebate-sensitive segment dominates the negative effect of intensifying competition in the rebate-insensitive segment.

Now consider the case when the retailer can sequentially subsidize the manufacturers to offer rebate programs. We fully characterize the retailer's optimal subsidy strategy. Subsidy always benefits the retailer but may benefit or hurt the manufacturer(s). A manufacturer is generally worse off when the retailer subsidizes the rival manufacturer to offer rebate. The only exception is when competition is not intense and the manufacturer currently offers rebate. This can be explained by how the rival manufacturer's rebate program softens and intensifies competition in respectively the rebate-insensitive and rebate-sensitive segments, as described earlier. Interestingly, when the retailer wants to induce both manufacturers to offer rebate, he always prefers to subsidize the manufacturer with a higher fixed cost first. Sometimes the other manufacturer will then voluntarily offer rebate even without subsidy.

We extend the base model to two different cases. In the first extension, we allow the low redemption cost to be positive whereas the high redemption cost is still very high. In the second extension, we assume that the redemption cost follows a uniform distribution and every consumer underestimates his redemption cost. The analytical results in the first extension and the numerical results in the second extension show that the main insights from the base model remain intact.

2. Literature Review

This study is closely related to the literature on rebate programs in supply chain management. Most papers in this stream consider a one-manufacturer-one-retailer relationship. Gerstner and Hess (1991) investigate the roles of trade deal, manufacturer rebate and retailer rebate in motivating the retailer to sell to a market with two consumer segments. Gerstner et al. (1994) examine how the retail markup impacts supply chain decisions regarding wholesale price, rebate value and retail price. In these pioneering works, the authors use rebates and coupons interchangeably. Chen et al. (2005) interpret rebate as a state-dependent discount because it is redeemed after purchase whereas coupons are redeemed at the purchase. Therefore, rebates have the ability to price discriminate within a consumer among his post-purchase states and are superior to coupons. Lu and Moorthy (2007) point out that rebates are different from coupons in when the uncertainty of the redemption cost is resolved: With coupons the uncertainty is resolved before purchase; with rebates the uncertainty is resolved after purchase. They show that rebates are more efficient than coupons in price discrimination. Khouja and Jing (2010) examine a manufacturer's incentive in issuing mail-in rebates in a one-to-one supply chain and find that rebates are profitable for manufacturer if consumers are inconsistent in their valuation of rebate when and after they make the purchase.

There are a number of papers that address the rebate decisions with uncertain demand. Chen et al. (2007) study the impact of manufacturer rebates on the firms' profits in a supply chain with demand uncertainty. They show that manufacturer rebates always benefit manufacturer unless the redemption rate is 100%. Aydin and Porteus (2009) extend the setting of Chen et al. (2007) to consider both channel rebates (from the manufacturer to the retailer) and manufacturer rebates with exogenous wholesale price when the demand function has multiplicative form. Demirag et al. (2010) consider a manufacturer's optimal rebate and retailer incentive policy when there is demand uncertainty and the retailer can price discriminate. Geng and Mallik (2011) examine a setting where both a manufacturer and a retailer decide whether to offer mail-in rebates to consumers in a newsvendor framework.

This study is most related to Cho et al. (2009). They consider a one-to-one supply chain and investigate how the manufacturer and the retailer independently make rebate decisions when there is a fixed cost associated with offering a rebate program. Similar to our study, they also consider the slippage effect as the driver of a rebate program. However, they consider vertical competition between the manufacturer and the retailer in offering rebate while we consider horizontal competition between manufacturers in offering rebate. Huang et al. (2013) comment that all the rebate-dependent demand models in the supply chain literature have considered only a setting with one manufacturer and one retailer. To the best of our knowledge, this study is the first to consider horizontal competition between manufacturers with rebate programs.

We are among the first to study manufacturer rebate competition. As far as we know, Demirag et al. (2011) is the only other paper that considers this issue. However, we focus on slippage effect, which is not considered by them. As a result, without competition, rebate may increase firms' profits in our model but it does not affect firms' profits in their model. Moreover, in their model, there are two competing supply chains, the retailers make quantity instead of price decisions, the manufacturers offer both consumer rebates and retailer incentives, and rebate is instantaneous with 100% redemption rate. Thus their model setup is also quite different from ours.

Our study is also related to the literature on manufacturer competition in a supply chain with a common retailer. Choi (1991) and Lee and Staelin (1997) study the case of linear wholesale price contracts. Cachon and Kök (2010) examine other contract forms and provide a comprehensive review of the literature. More recently, Cai et al. (2013) examine the role of probabilistic selling. Bandyopadhyay and Paul (2010) and Lan et al. (2013) analyze the equilibrium return policies when demand is uncertain. Our study contributes to this body of work by considering manufacturer competition in both wholesale prices and rebate values.

3. The Model

3.1. Model Setup

We consider a model with two manufacturers (indexed by 1 or 2) selling substitutable products through a common retailer (he). If manufacturer i (she) decides to offer a rebate program, she incurs a fixed cost F_i, which captures the costs associated with launching a rebate promotion, advertising, and distribution and processing fees.

We consider a multi-stage game with the following sequence of events:

1. Each manufacturer i decides whether to offer rebate with an associated fixed cost F_i. Let $Z_i = R$ if she offers a rebate program and $Z_i = N$ otherwise. Let n be the number of rebate programs offered, where n = 0, 1, 2.
2. After observing the rebate program decisions, each manufacturer i determines her wholesale price w_i, and rebate value r_i if a rebate program is in place.
3. The retailer determines the retail prices p_1 and p_2 for both products, given the wholesale prices and rebate values.
4. The manufacturers produce to meet their demands and the firms receive their payoffs.

Without loss of generality, we assume that the unit manufacturing cost, the unit selling cost and the unit rebate processing cost are constant and normalized to zero. We also assume that the manufacturers have to commit on offering a rebate program before other decisions because it takes time to launch the rebate program, e.g., setting up the website and the rebate center. Moreover, manufacturers determine wholesale prices and rebate values simultaneously because a manufacturer cannot commit on these decisions to influence the rival manufacturer's decisions.

3.2. Demand Functions

A consumer incurs a unit cost in redeeming rebate, which can be either c_H or c_L, with $c_H > c_L \geq 0$. As discussed in Lu and Moorthy (2007) and Banks and Moorthy (1999), higher-income consumers have larger redemption costs because of their greater opportunity cost of time. A consumer makes purchasing decision based on his estimated redemption cost. We derive the demand functions from consumers' primitive utility functions by following the approach from Vives (1999). See also Cai et al. (2012) for a similar approach. The utility function of a representative consumer is given by:

$$(q_1 + q_2)a - \frac{1}{2}\left((q_1)^2 + (q_2)^2 + 2\gamma q_1 q_2\right) - (p_1 - \max[0, r_1 - c])q_1 - (p_2 - \max[0, r_2 - c])q_2,$$

where a is the market size, p_i, r_i and q_i are respectively the retail price, rebate value and purchasing quantity of product i, and c is the consumer's estimated redemption cost. Here $\gamma \in [0, 1)$ captures the substitutability between the two products, generally interpreted as the competition intensity. A consumer whose redemption cost is c_L always estimates his cost correctly (i.e., $c = c_L$), but a consumer whose redemption cost is c_H may underestimate his cost (i.e., c may be c_H or c_L). As pointed out by Chen et al. (2007), there is empirical evidence that consumers systematically underestimate the future effort in the context of delayed reward and the purchase decision is independent of the decision to redeem the rebate later. Tasoff and Letzler (2014) think of the possibility of forgetting, losing the form, and other events that preclude redemption as drawing an arbitrarily high cost.

For the purpose of tractability, we assume that $c_L = 0$ and c_H is very high such that it prohibits a consumer from redeeming rebate. The opportunity cost of time can be very high for some consumers. According to Inmar (2015), 58% of shoppers say there are too many rules and exclusions to use rebates. In Consumer Reports magazine (2009), 25% of consumers never send in rebates and the dominant reason is "too many steps." So the assumption of a very high c_H relative to rebate value is reasonable as long as the equilibrium rebate value is not too high, say, relative to other values such as the wholesale prices.

To show that the assumptions of the base model are not restrictive, we consider two extensions in section 7. In the first extension, we allow c_L to be positive. In the second extension, we assume that the redemption cost follows a uniform distribution and every consumer underestimates his redemption cost. Our analytical and numerical results in these two extensions show that most of the main insights in the base model remain intact.

Given the redemption cost has a binary distribution (with a value of c_H or c_L), there are two segments with consumers who are respectively rebate-insensitive (the estimated redemption cost is c_H) and rebate-sensitive (the estimated redemption cost is c_L). In the rebate-insensitive segment, all the consumers correctly estimate their redemption cost to be c_H at the time when they make purchasing decisions. In the rebate-sensitive segment, some consumers underestimate their redemption costs to be c_L at the time when they make purchasing decisions and do not redeem rebates afterwards because their actual redemption costs are c_H. We call this the slippage effect and because of this, the rebate redemption rate, m, is strictly less than 100%. Let β ($0 < \beta < 1$) be the proportion of rebate-sensitive consumers in the market. Without loss of generality, we normalize the consumer base to 1.

The utility function of a representative rebate-sensitive consumer is given by the following:

$$(q_1 + q_2)a - \frac{1}{2}\left((q_1)^2 + (q_2)^2 + 2\gamma q_1 q_2\right) - (p_1 - r_1)q_1 - (p_2 - r_2)q_2.$$

Given p_1, p_2, r_1 and r_2, the optimal consumption quantities y_1 and y_2 for the rebate-sensitive consumers who consider rebate are given by the following:

$$y_1 = \frac{(1-\gamma)a - (p_1 - r_1) + \gamma(p_2 - r_2)}{1-\gamma^2},$$
$$y_2 = \frac{(1-\gamma)a - (p_2 - r_2) + \gamma(p_1 - r_1)}{1-\gamma^2}.$$

These are the demand functions for the rebate-sensitive segment.

The utility function of a representative rebate-insensitive consumer is given by:

$$(q_1 + q_2)a - \frac{1}{2}\left((q_1)^2 + (q_2)^2 + 2\gamma q_1 q_2\right) - p_1 q_1 - p_2 q_2.$$

Given p_1 and p_2, the optimal consumption quantities x_1 and x_2 for the rebate-insensitive consumers who do not consider rebate are given by:

$$x_1 = \frac{(1-\gamma)a - p_1 + \gamma p_2}{1-\gamma^2},$$
$$x_2 = \frac{(1-\gamma)a - p_2 + \gamma p_1}{1-\gamma^2}.$$

These are the demand functions for the rebate-insensitive segment. The demand functions of such form have appeared quite extensively in the literature (see, for instance, Choi 1991, Lee and Staelin 1997, Shin and Tunca 2010, and Vives 1999).

REMARK 1. We assume that each consumer incurs a variable redemption cost per unit of purchasing quantity. We have also considered the case of a fixed redemption cost and found that all qualitative results remain valid.

We restrict to a decision space such that the demands in both segments, that is, x_i and y_i, can be assumed to be positive. Cho et al. (2009) make a similar assumption that demand is always positive with either sales price or regular price. Without such an assumption, a manufacturer can always increase profit by increasing both the wholesale price and the rebate value, while maintaining a constant demand in the rebate-sensitive segment and zero demand in the rebate-insensitive segment. This is not realistic for the following reasons. First, it is against the law to charge a price that is deceptively high if the firm uses it to trick the consumers into buying the product (Federal Trade Commission 1967). Second, consumers may not buy the product when they find the retail price to be unreasonably high (Urbany et al. 1988). Third, it rarely happens in practice that a manufacturer sells to only the rebate-sensitive segment, and such a case would not be interesting anyway. To this end, we need the technical conditions $\frac{\gamma}{2+\gamma} < m < 1$ and $\beta < \min\left[\frac{2m}{1+m}, \frac{2(2+\gamma)((2+\gamma)m-\gamma)}{1+(1+\gamma)m(6+m)-3\gamma-2\gamma^2(1-m)}\right]$ to make our model realistic and practically interesting.

4. Price and Rebate Value Decisions

Given manufacturers' rebate decisions (Z_1, Z_2), we solve for the equilibrium retail prices, wholesale prices and rebate values and then derive the firms' profits. The fixed cost of a rebate program is not relevant because it is a sunk cost that does not have any impact on the price and rebate value decisions. Let $\pi_{Mi}(n)$ ($n = 0, 2$) or $\pi_{Mi}^{Z_i}(n)$ ($n = 1$) be manufacturer i's equilibrium profit, and $\pi_R(n)$ ($n = 0, 1, 2$) be the retailer's equilibrium profit when the number of rebate programs is n.

Given w_i and r_i, the retailer maximizes his profit

$$(p_1 - w_1)[\beta y_1 + (1-\beta)x_1] + (p_2 - w_2)[\beta y_2 + (1-\beta)x_2],$$

by choosing the following best-response function:

$$\hat{p}_i(w_i, r_i) = \frac{1}{2}(a + w_i + \beta r_i). \tag{1}$$

4.1. Neither Manufacturer Offers Rebate

If neither manufacturer offers rebate program, manufacturer i maximizes her profit

$$w_i[\beta y_i + (1-\beta)x_i],$$

with the following best-response function:

$$\hat{w}_i(w_j) = \frac{(1-\gamma)a + \gamma w_j}{2}.$$

By solving $w_i = \hat{w}_i(w_j)$ and $w_j = \hat{w}_j(w_i)$ simultaneously, we obtain the equilibrium wholesale prices

$$w_i(0) = \frac{(1-\gamma)a}{2-\gamma}.$$

Substituting $w_i = w_i(0)$ and $r_i = 0$ into the retailer's best-response function $\hat{p}_i(w_i, r_i)$ given by Equation (1), we obtain the equilibrium retail prices and profits

$$p_i(0) = \frac{(3-2\gamma)a}{2(2-\gamma)},$$
$$\pi_R(0) = \frac{a^2}{2(2-\gamma)^2(1+\gamma)},$$
$$\pi_{Mi}(0) = \frac{(1-\gamma)a^2}{2(2-\gamma)^2(1+\gamma)}.$$

LEMMA 1. (*a*) *$p_i(0)$ and $w_i(0)$ (i = 1, 2) are decreasing in γ; (b) $\pi_{Mi}(0)$ is decreasing in γ, and $\pi_R(0)$ is increasing in γ.*

All proofs are given in the online Appendix.

4.2. Both Manufacturers Offer Rebate

If both manufacturers have rebate programs, manufacturer i maximizes her profit

$$\beta(w_i - mr_i)y_i + (1-\beta)w_i x_i,$$

by choosing the following best-response functions:

$$\hat{r}_i(r_j, w_j) = \frac{(1-\gamma)(1-m)a + \gamma\left[(m(4-3\beta)-\beta)r_j + (1-m)w_j\right]}{h(m,\beta)}$$

$$\hat{w}_i(r_j, w_j) = \frac{\{(1-\gamma)m(4-(3+m)\beta)a + \gamma m\left[(4-(3+m)\beta)w_j - (1-m)(2-\beta)\beta r_j\right]\}}{h(m,\beta)},$$

where

$$h(m,\beta) \equiv 8m - \beta(m^2 + 6m + 1) > 0.$$

By solving the four equations $r_i = \hat{r}_i(r_j, w_j)$ and $w_i = \hat{w}_i(r_j, w_j)$ simultaneously, we obtain the manufacturers' equilibrium decisions:

$$w_i(2) = \frac{[2(2-\gamma) - \beta(3+m-2\gamma)](1-\gamma)ma}{2(1-\beta)\gamma^2 m + (1-\gamma)h(m,\beta)},$$
$$r_i(2) = \frac{(1-\gamma)(1-m)a}{2(1-\beta)\gamma^2 m + (1-\gamma)h(m,\beta)}.$$

Substituting $w_i = w_i(2)$ and $r_i = r_i(2)$ into the retailer's best-response function $\hat{p}_i(w_i, r_i)$ given by Equation (1), we obtain the equilibrium retail prices and profits:

$$p_i(2) = \frac{[2(1-\beta)\gamma^2 - 7\gamma + \beta\gamma(m+6) - \beta(m+5) + 6]ma}{2\gamma^2(1-\beta)m + (1-\gamma)h(m,\beta)},$$

$$\pi_R(2) = \frac{2(1-\beta)^2(2-\gamma)^2 m^2 a^2}{(1+\gamma)[(1-\gamma^2)h(m,\beta) + 2\gamma^2(1+\gamma)m(1-\beta)]^2},$$

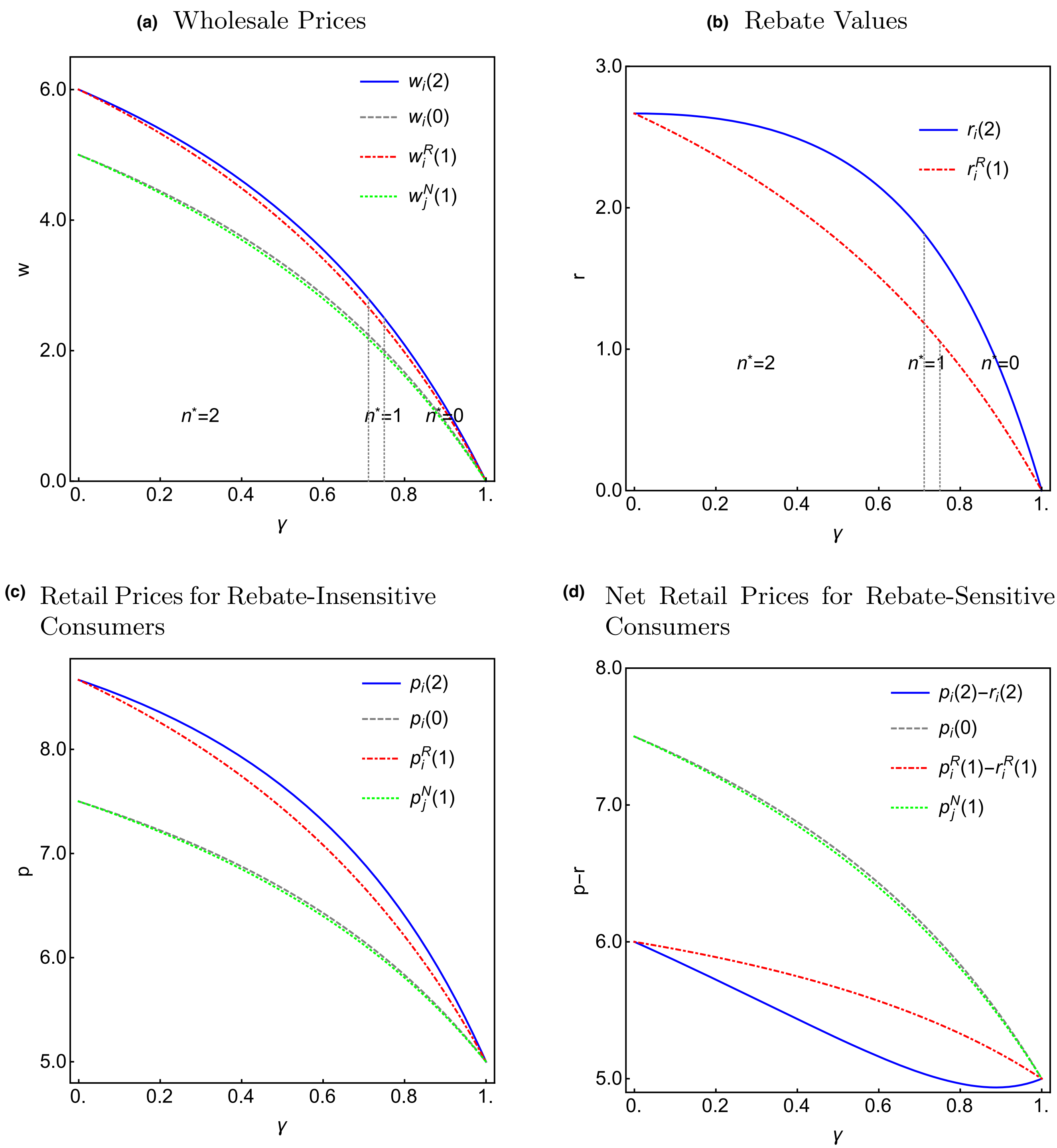
$$\pi_{Mi}(2) = \frac{(1-\beta)(1-\gamma)ma^2}{(1-\gamma^2)h(m,\beta) + 2\gamma^2(1+\gamma)m(1-\beta)}.$$

Overage, that is, $p_i(2) < r_i(2)$, could occur in our model. That means after claiming and collecting the rebate from the manufacturer, a consumer not only gets the product for free but also earns some extra money. It is not uncommon to have overage in real life. For example, Cascade Platinum dishwasher detergent is sold in Walmart at \$3.97 and one can claim \$5 mail-in rebate from the manufacturer (Faithfulsaver.com 2014). Overage happens when $\beta > \frac{\gamma + 2\gamma^2 m - 8\gamma m + 7m - 1}{m(2\gamma^2 - 6\gamma - \gamma m + m + 5)}$, that is, the proportion of rebate-sensitive consumers is large, because the manufacturer relies more on selling to the rebate-sensitive segment.

LEMMA 2. (*a*) *$p_i(2)$, $w_i(2)$ and $r_i(2)$ are decreasing in γ and m, and increasing in β.* (*b*) *$\pi_{Mi}(2)$ is decreasing in γ and m, and increasing in β; $\pi_R(2)$ is decreasing in m, and increasing in γ and β.*

The effects of β and m are unsurprising. Because rebate is usually regarded as a form of price competition and pro-competitive, one might expect that more intense competition would induce a manufacturer to raise her rebate value to obtain a larger market share. However, our analysis shows that such a conjecture is not necessarily correct. It would be true if the wholesale price is fixed.

Figure 1 Equilibrium Wholesale Price, Rebate Value and (Net) Retail Price Versus Competition Intensity (a = 10, m = 1/2, β = 1/2, F_1 = 1/5, F_2 = 1/2) [Color figure can be viewed at wileyonlinelibrary.com]



However if the manufacturer can adjust both the wholesale price and rebate value, she would lower both when competition is more intense (Figure 1a and b). This can be explained as follows. More intense competition has opposing effects on the rebate value. On the one hand, as the wholesale price decreases, the manufacturer wants to lower the rebate value to maintain a healthy profit margin ($w - mr$) for the rebate-sensitive segment. In addition, a lower rebate value induces a lower retail price which increases the demand from the rebate-insensitive segment. On the other hand, when competition is more intense, the manufacturer wants to increase the rebate value to induce a lower net retail price to stimulate more demand from the rebate-sensitive segment. However, this is less effective because a larger rebate value induces the retailer to charge a higher retail price, which dilutes the effect of rebate on the rebate-sensitive segment. It turns out that the former two effects together dominate the latter one as competition intensifies.

Manufacturer competition benefits the consumers in the rebate-insensitive segment because the retail price is decreasing in γ (Figure 1c). However, the impact of manufacturer competition on the consumers in the rebate-sensitive segment is ambiguous because both the retail price and the rebate value are decreasing in γ. We can show that the net retail price for the rebate-sensitive consumer is first decreasing and then increasing when competition becomes more intense (Figure 1d). It can be higher with competition than without when γ is sufficiently high. In other words, manufacturer competition does not necessarily benefit consumers in the rebate-sensitive segment.

4.3. One Manufacturer Offers Rebate

Suppose manufacturer i issues rebate and manufacturer j does not. Manufacturer i maximizes her profit by choosing the following best-response functions:

$$\hat{r}_i(w_j) = \frac{(1-m)\left[(1-\gamma)a + \gamma w_j\right]}{h(m,\beta)},$$
$$\hat{w}_i(w_j) = \frac{m[4-(3+m)\beta]\left[(1-\gamma)a + \gamma w_j\right]}{h(m,\beta)}.$$

Manufacturer j maximizes her profit by choosing the following best-response function:

$$\hat{w}_j(r_i, w_i) = \frac{(1-\gamma)a + \gamma(w_i - \beta r_i)}{2}.$$

By solving $r_i = \hat{r}_i(w_j)$, $w_i = \hat{w}_i(w_j)$ and $w_j = \hat{w}_j(r_i, w_i)$ simultaneously, we obtain the manufacturers' equilibrium decisions:

$$w_i^R(1) = \frac{(1-\gamma)(2+\gamma)[4-(3+m)\beta]ma}{4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)},$$
$$r_i^R(1) = \frac{(1-\gamma)(2+\gamma)(1-m)a}{4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)},$$
$$w_j^N(1) = \frac{(1-\gamma)[(1+\gamma)h(m,\beta) - 4\gamma(1-\beta)m]a}{4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)},$$

where $w_i^R(1) > w_j^N(1)$. Substituting $w_i = w_i^R(1)$, $r_i = r_i^R(1)$, $w_j = w_j^N(1)$ and $r_j = 0$ into the retailer's best-response functions $\hat{p}_i(w_i, r_i)$ and $\hat{p}_j(w_j, r_j)$ given by Equation (1), we obtain the equilibrium retail prices and profits:

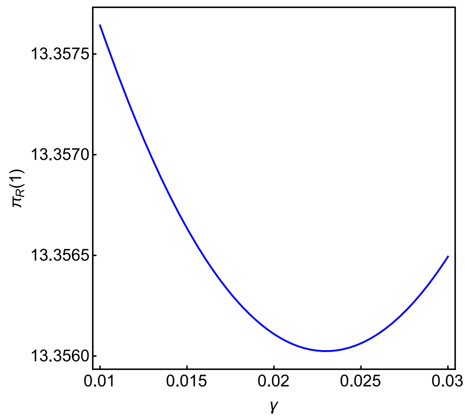
$$p_i^R(1) = \frac{a}{2}\left[1 + \frac{(1-\gamma)(2+\gamma)(2\beta - 4m + 2\beta m + h(m,\beta))}{4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)}\right],$$
$$p_j^N(1) = \frac{a}{2}\left[1 + \frac{(1-\gamma)[(1+\gamma)h(m,\beta) - 4m(1-\beta)\gamma]}{4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)}\right],$$
$$\pi_R(1) = \frac{h_1(m,\beta)a^2}{4(1+\gamma)[4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)]^2},$$
$$\pi_{Mi}^R(1) = \frac{(1-\beta)(2+\gamma)^2(1-\gamma)mh(m,\beta)a^2}{(1+\gamma)[4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)]^2},$$
$$\pi_{Mj}^N(1) = \frac{(1-\gamma)[(1+\gamma)h(m,\beta) - 4m(1-\beta)\gamma]^2a^2}{2(1+\gamma)[4m(1-\beta)\gamma^2 + (2-\gamma^2)h(m,\beta)]^2},$$

where $h_1(m, \beta) = (1 + \gamma)h^2(m, \beta) + 8m(1 - \beta)[\gamma(1 + \gamma) h(m, \beta) + 4m(1 - \beta)(2 - \gamma^2)]$. Rebate-sensitive consumers perceive a higher net retail price for product j than product i ($p_j^N(1) > p_i^R(1) - r_i^R(1)$), whereas rebate-insensitive consumers face a higher price for product i than product j ($p_i^R(1) > p_j^N(1)$). For a rebate-sensitive consumer, we can show that manufacturer i makes more profit from selling a product to him than manufacturer j, and the retailer earns more profit from selling product i to him than product j. The reverse is true for a rebate-insensitive consumer.

Lemma 3. *(a) $p_i^R(1)$, $w_i^R(1)$ and $r_i^R(1)$ are decreasing in γ and m, and increasing in β; $p_j^N(1)$ and $w_j^N(1)$ are decreasing in γ and β, and increasing in m. (b) $\pi_{Mi}^R(1)$ is decreasing in γ and m, and increasing in β; $\pi_{Mj}^N(1)$ is decreasing in γ and β, and increasing in m; $\pi_R(1)$ is first decreasing and then increasing in γ, increasing in β, and decreasing in m.*

When the rebate-sensitive segment is larger, or the redemption rate is lower, manufacturer j who does not issue rebate is more disadvantaged for not having the flexibility of using both wholesale price and rebate value to influence the (net) retail prices in both consumer segments. When only one manufacturer offers rebate program, as illustrated in Figure 2, the retailer's profit is first decreasing and then increasing as competition becomes more intense, in contrast to the case where both manufacturers offer rebate programs. When competition is more intense, the retailer benefits from lower w_i and w_j, but is hurt by a lower r_i. Our results show that the effect of competition on retailer's profit from product i can be negative and it can dominate the positive effect of competition on his profit from product j.

Figure 2 Retailer Profit Versus Competition Intensity (a = 10, m = 1/2, β = 1/2) [Color figure can be viewed at wileyonlinelibrary.com]



5. Rebate Decisions

5.1. Single Manufacturer

To isolate the effect of manufacturer competition, we first study the case of a single manufacturer by setting $\gamma = 0$ and focusing on the game between one manufacturer and the retailer. Let π_R^Z and π_M^Z be retailer's and manufacturer's equilibrium profits given manufacturer's rebate decision $Z = R, N$.

Proposition 1. *For the case of a single manufacturer: (a) The manufacturer offers rebate if and only if $F \le T_0 = \pi_M^R - \pi_M^N = \frac{\beta(1-m)^2 a^2}{8h(m,\beta)}$. (b) T_0 is increasing in a and β, and decreasing in m. (c) $\pi_R^R > \pi_R^N$.*

From parts (a) and (b), the manufacturer offers rebate if the fixed cost of the rebate program is low, the total market size is large, the proportion of rebate-sensitive segment is high or redemption rate is low. From part (c), the retailer always benefits when the manufacturer offers a rebate program.

Consider the rebate decision that maximizes the total supply chain profit. It is straightforward to show that manufacturer rebate increases the supply chain profit iff

$$F \le T_s = \frac{\beta(1-m)^2(32m - \beta(3m^2 + 26m + 3))a^2}{16h^2(m,\beta)},$$

where T_s is increasing in a and β and decreasing in m. We can show that $T_s > T_0$ and it follows that the retailer can use subsidy to induce manufacturer to make the rebate decision that maximizes the total supply chain profit. When $T_0 < F \le T_s$, he will offer a subsidy of $F - T_0$ to induce the manufacturer to offer rebate.

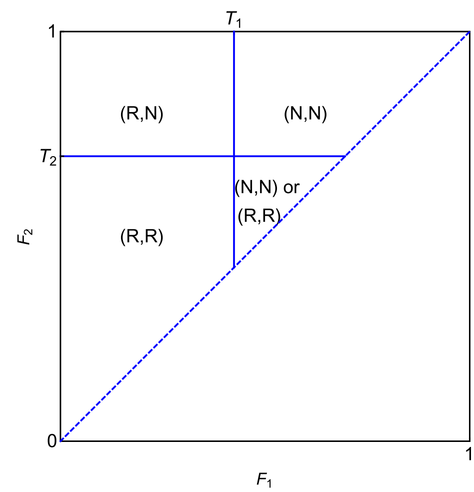
5.2. Competing Manufacturers

Next, we study the case when $\gamma > 0$. In the first stage, the manufacturers simultaneously decide whether or

Table 1 Payoff Matrix of the Stage-1 Game

Manufacturer 1 \ Manufacturer 2	$Z_2 = R$	$Z_2 = N$
$Z_1 = R$	$\pi_{M1}(2) - F_1$, $\pi_{M2}(2) - F_2$	$\pi_{M1}^R(1) - F_1$, $\pi_{M2}^N(1)$
$Z_1 = N$	$\pi_{M1}^N(1)$, $\pi_{M2}^R(1) - F_2$	$\pi_{M1}(0)$, $\pi_{M2}(0)$

Figure 3 Equilibrium Rebate Decisions (a = 10, m = 1/2, β = 1/2, γ = 1/2) [Color figure can be viewed at wileyonlinelibrary.com]



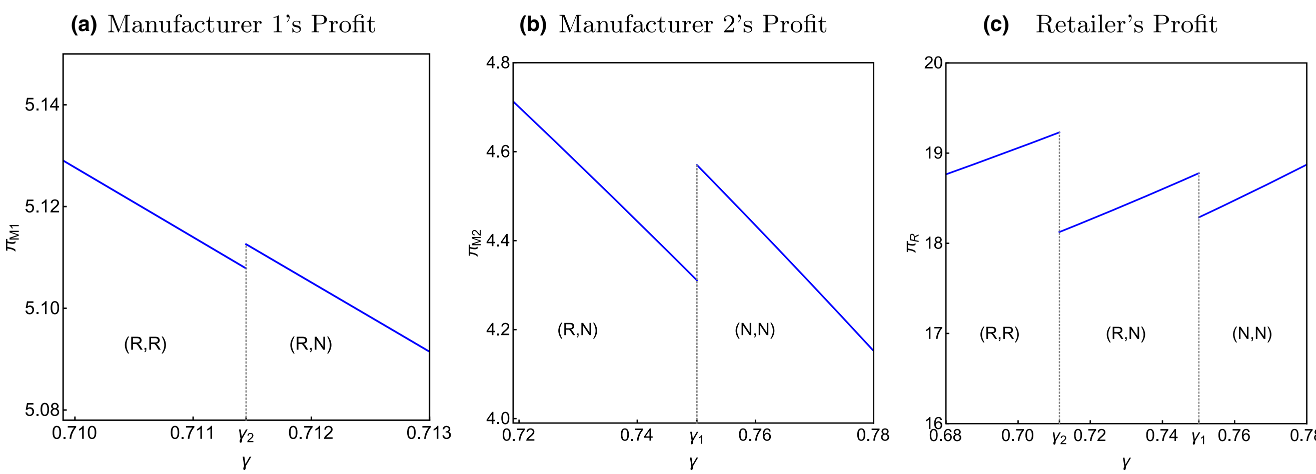
not to pay a fixed cost to launch a rebate program. Let F_i be the fixed cost of manufacturer i. Without loss of generality we assume $F_1 \le F_2$. We can construct a normal game with the manufacturers as players and a payoff matrix given by Table 1. We assume that a manufacturer will offer rebate if she is indifferent to doing so or not.

Let $T_1 \equiv \pi_{Mi}^R(1) - \pi_{Mi}(0)$, $T_2 \equiv \pi_{Mi}(2) - \pi_{Mi}^N(1)$, and $T_3 \equiv \pi_{Mi}(2) - \pi_{Mi}(0)$, where T_1, T_2, T_3 are functions of a, γ, β and m. We can show that $0 < T_1 < T_2$ and $0 < T_3 < T_2$. The following proposition presents the equilibrium rebate structure and it is illustrated in Figure 3.

Proposition 2. *(a) Suppose $F_1 \le F_2$. (1) If $F_1 > T_1$ and $F_2 > T_2$, (N, N) is the unique equilibrium; (2) If $F_1 < T_1$ and $F_2 \le T_2$, (R, R) is the unique equilibrium; (3) If $T_1 \le F_i \le T_2$, (N, N) and (R, R) are the (only) two equilibria. (N, N) is Pareto optimal if either $T_3 < T_1$ or $T_1 < T_3 < F_i < T_2$; (R, R) is Pareto optimal if $T_1 < F_i < T_3 < T_2$; (N, N) and (R, R) do not dominate each other otherwise. (4) If $F_1 \le T_1$ and $F_2 > T_2$, (R, N) is the unique equilibrium. (b) T_1, T_2 and T_3 are decreasing in γ and m, and increasing in a and β.*

From part (a), both manufacturers offer rebate if their fixed costs are low, and none of them offers rebate when their fixed costs are high. Otherwise only the

Figure 4 Equilibrium Firms' Profits Versus Competition Intensity (a = 10, m = 1/2, β = 1/2, F_1 = 1/5, F_2 = 1/2) [Color figure can be viewed at wileyonlinelibrary.com]



manufacturer with a lower fixed cost offers rebate. If $T_3 < F_i < T_1$ for i = 1 and 2, (R, R) is the unique equilibrium but both manufacturers would be better off with (N, N). This is the classical prisoners' dilemma. When a manufacturer offers rebate, the rival manufacturer will do so too or else she will become disadvantaged. From part (b), when the rebate-sensitive segment is larger, the actual redemption rate is lower, or the total market size is larger, it is more likely for the manufacturers to offer rebate. However, when competition is more intense, it is less likely for the manufacturers to offer rebate as explained after Lemma 2. Our results provide a plausible explanation of why Dell and HP have phased out their rebate programs whereas others (e.g., Sony and Samsung) have not.

Corollary 1. *Suppose $F_1 = F_2 = F$. (a) When $F < T_1$, (R, R) is the unique equilibrium; (b) When $T_1 \leq F \leq T_2$, (N, N) and (R, R) are the (only) two equilibria and (R, R) is Pareto optimal if $F < T_3$, and (N, N) is Pareto optimal otherwise; (c) When $F > T_2$, (N, N) is the unique equilibrium.*

The following proposition presents some sensitivity results and compares the retailer's profits under different numbers of rebate programs.

Proposition 3. *Suppose $F_1 \leq F_2$. (a) When an increase in γ, m or F_2 or a decrease in a or β induces the equilibrium to change from (R, R) to (R, N), manufacturer 1 is better off if $\gamma > \bar{\gamma}$ and worse off otherwise, and the retailer is worse off. (b) When an increase in γ, m or F_1 or a decrease in a or β induces the equilibrium to change from (R, N) to (N, N), manufacturer 2 is better off, and the retailer is worse off. (c) $\pi_R(0) < \pi_R(1) < \pi_R(2)$.*

Without rebate, it is known that more intense competition or a smaller market size hurts the manufacturers. With rebate, however, from part (a), when more intense competition induces the rival manufacturer to cease offering rebate, it benefits a rebate-offering manufacturer if competition is intense, as illustrated in Figure 4a, and hurts her otherwise.

Similarly, a smaller market size benefits a rebate-offering manufacturer when it induces the rival manufacturer to cease offering rebate and competition is intense. These results can be explained as follows. Suppose both manufacturers offer rebate. When one manufacturer stops offering rebate, both manufacturers lower their wholesale prices ($w_j^N(1) < w_i^R(1) < w_i(2)$ in Figure 1a) and the rebate-offering manufacturer also lowers her rebate value ($r_i^R(1) < r_i(2)$ in Figure 1b). This intensifies competition in the rebate-insensitive segment ($p_i(2) > p_i^R(1) > p_j^R(1)$ in Figure 1c) but softens it in the rebate-sensitive segment ($p_j^R(1) > p_i^R(1) - r_i^R(1) > p_i(2) - r_i(2)$ in Figure 1d). When competition is more intense, the manufacturers compete more fiercely in the rebate-sensitive segment when both offer rebate, and therefore the positive effect of softening competition in the rebate-sensitive segment dominates the negative effect of intensifying competition in the rebate-insensitive segment.

Without competition, a manufacturer who offers rebate is worse off when redemption rate becomes higher or the rebate-sensitive segment becomes smaller. With competition, however, a rebate-offering manufacturer could be better off if either change induces the rival manufacturer to cease offering rebate and competition is intense, as explained earlier. Part (a) also shows that when competition is not intense and the rival manufacturer stops offering rebate due to a higher fixed cost, a rebate-offering manufacturer could become worse off.

From part (b), a non-rebate-offering manufacturer benefits from more intense competition, as illustrated in Figure 4b, if it induces the rival manufacturer to cease offering rebate. This is because the rival manufacturer loses the flexibility of using rebate to influence competition. Consequently, the non-rebate-offering manufacturer raises her wholesale price ($w_i^N(1) < w_i(0)$), whereas the rival manufacturer lowers the wholesale price ($w_i(0) < w_i^R(1)$), as illustrated in Figure 1a. Similarly, a smaller market size benefits the non-rebate-offering manufacturer when it induces the rival manufacturer to stop offering rebate.

From part (c), the retailer always benefits from manufacturer rebate because it is a cost effective way to stimulate demand. This explains the result in parts (a) and (b) that the retailer is worse off when a change in a parameter induces a manufacturer to stop offering rebate. This is illustrated in Figure 4c for the case of competition intensity.

Our results have important implications to rebate programs in practice. Proposition 2 may explain why a manufacturer (e.g., Samsung) offers rebate while her rival (e.g., HP) does not. This could be because they face different fixed costs, and the competition intensity is neither too high nor too low such that it is only profitable for some but not all of the manufacturers to offer rebate. Proposition 3 shows that a change in the business environment (e.g., redemption rate becomes lower) that normally benefits a rebate-offering manufacturer could hurt her if it motivates a rival manufacturer to start offering rebate. It also suggests that a retailer should be cautious in taking actions to intensify the competition between his vendors, because such actions might induce a vendor to cease offering rebate and hurt the retailer.

6. Retailer Subsidizes Manufacturer Rebate

In this section, we study how the retailer should offer subsidy to induce the manufacturer(s) to offer more rebate programs. We assume that the retailer makes offers to the manufacturers sequentially. (We have also considered the case of simultaneous offering and, because the results are qualitatively similar, details are omitted.) Let S_i ($i = 1, 2$) be the subsidy offered to manufacturer i. Let $V_1 = \pi_R(1) - \pi_R(0) + T_1$ and $V_2 = \pi_R(2) - \pi_R(1) + T_2$. Figure 5 illustrates the equilibrium rebate decisions. In Figure 6, we impose the equilibrium structure of Figure 3 into Figure 5 to highlight the changes due to subsidy. The corresponding regions are denoted by A to I, and their definitions are given in the online Appendix.

Proposition 4. *The equilibrium rebate and subsidy decisions are given in Table* 2. *When the retailer uses subsidy to induce the equilibrium to change from* (N, N) *to* (R, R), *he always prefers to subsidize the manufacturer with a higher fixed cost* (*i.e., manufacturer* 2) *first.*

Figure 5 Equilibrium Rebate Decisions with Retailer's Subsidy (a = 10, m = 1/2, β = 1/2, γ = 1/2) [Color figure can be viewed at wileyonlinelibrary.com]

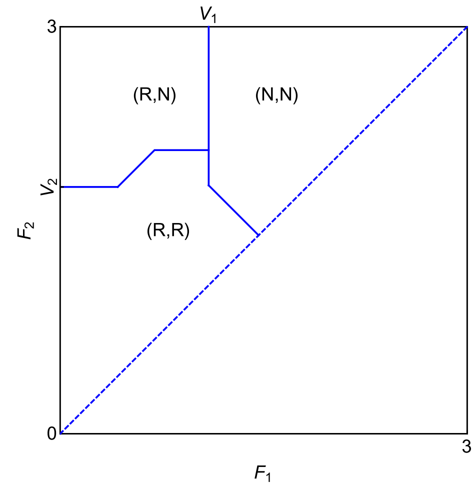
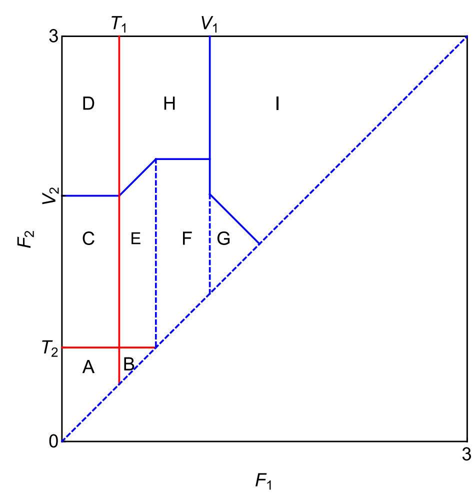


Figure 6 Effect of Retailer's Subsidy (a = 10, m = 1/2, β = 1/2, γ = 1/2) [Color figure can be viewed at wileyonlinelibrary.com]



Compared with the case of no subsidy, the manufacturers are obviously more likely to offer rebate. The retailer may subsidize manufacturer 1 to induce a change in the equilibrium rebate decisions from (N, N) to (R, N) (Region H), or subsidize manufacturer 2 to induce a change from (R, N) to (R, R) (Region C). If he wants to induce a change from (N, N) to (R, R), he always prefers to subsidize manufacturer 2 first because she has a higher fixed cost. By doing so, he can either induce manufacturer 1 to voluntarily offer rebate (Region E), or lower the total subsidy cost to both manufacturers (Region F). This is because after the first

Table 2 Equilibrium Rebate and Subsidy Decisions

Rebate decisions without subsidy	Rebate decisions with subsidy	Subsidy values	Regions
(*R*, *R*)	(*R*, *R*)	$S_2 = 0$, $S_1 = 0$	A
(*R*, *R*) and (*N*, *N*)	(*R*, *R*)	$S_2 = 0$, $S_1 = 0$	B
(*R*, *N*)	(*R*, *R*)	$S_2 = F_2 - T_2$, $S_1 = 0$	C
	(*R*, *N*)	$S_2 = 0$, $S_1 = 0$	D
(*N*, *N*)	(*R*, *R*)	$S_2 = F_2 - T_2$, $S_1 = 0$	E
		$S_2 = F_2 - T_2$, $S_1 = F_1 - T_2$	F
		$S_2 = F_2 - T_3$, $S_1 = F_1 - T_2$	G
	(*R*, *N*)	$S_2 = 0$, $S_1 = F_1 - T_1$	H
	(*N*, *N*)	$S_2 = 0$, $S_1 = 0$	I

manufacturer has accepted the subsidy, it is easier to make the second manufacturer offer rebate if she is manufacturer 1 instead of manufacturer 2. We can show that if the retailer subsidizes manufacturer 1 first, it is impossible to induce manufacturer 2 to voluntarily offer rebate. In Region B, without subsidy, both equilibria (*R*, *R*) and (*N*, *N*) exist. With subsidy, the retailer can ensure that (*R*, *R*) is the unique equilibrium by first paying an arbitrarily small subsidy to manufacturer 2 for offering rebate, and then manufacturer 1 will follow by voluntarily offering rebate too.

As observed in section 1, both Epson and Canon offer rebates and sell their products through Staples, but Staples operates an online system to process rebates for Epson but not Canon. This could be explained by Proposition 4, which shows that a retailer may need to subsidize only one manufacturer to induce both to offer rebate.

Contrary to the single manufacturer case, subsidy does not always induce the rebate decisions that maximize supply chain profit. It always benefits the retailer because he offers subsidy only when it is profitable. The following proposition examines the impact of subsidy on the manufacturers' profits when it induces a change in the equilibrium rebate decisions.

Proposition 5. (*a*) *In Region C, when retailer's subsidy induces the equilibrium to change from* (*R*, *N*) *to* (*R*, *R*), *manufacturer* 1 *is better off if* $\gamma < \bar{\gamma}$ *and worse off otherwise.* (*b*) *In Region H, when retailer's subsidy induces the equilibrium to change from* (*N*, *N*) *to* (*R*, *N*), *manufacturer* 2 *is worse off.* (*c*) *In Regions E, F and G, when retailer's subsidy induces the equilibrium to change from* (*N*, *N*) *to* (*R*, *R*), *manufacturer* 1 *is strictly worse off and manufacturer* 2 *is weakly worse off.*

From parts (a) and (b), the results are similar to those in Proposition 3, because the manufacturer who is not subsidized does not change her rebate decision. Suppose the retailer subsidizes a manufacturer to offer rebate. If the rival manufacturer is not currently offering rebate (Region H), she is worse off. (For example, when Kohl's partners with Philips Sonicare Toothbrush to offer exclusive manufacturer rebate, other competing brands who do not offer rebate become worse off.) If the rival manufacturer is currently offering rebate (Region C), she is better off if competition is not intense and worse off otherwise, as explained in the previous section. (For instance, Asus offers rebate on its own and when Newegg.com works with MSI to offer exclusive manufacturer rebate, Asus could be better or worse off according to our results.) Now consider part (c). When the retailer uses subsidy to induce both manufacturers to offer rebate programs (Regions E, F, and G), manufacturer 1 is always strictly worse off. Manufacturer 2 is also strictly worse off in Regions E and F, but indifferent in Region G. In Regions E and F, a subsidized manufacturer can be worse off with subsidy than without because if she does not accept the offer while the rival manufacturer does, she would be worse off than the case when both do not offer rebate. In Region G, manufacturer 2, who is subsidized, is indifferent because the retailer would not offer any subsidy to manufacturer 1 if manufacturer 2 rejects the offer.

Besides the regions characterized by Proposition 5, it would be interesting to consider Region B too. Without subsidy, both (*N*, *N*) and (*R*, *R*) can be an equilibrium. Proposition 2 provides conditions under which (1) (*N*, *N*) is Pareto optimal, (2) (*R*, *R*) is Pareto optimal, and (3) (*N*, *N*) and (*R*, *R*) do not dominate each other. It is natural to pick the Pareto optimal equilibrium, if it exists, as the outcome of a game because it is preferred by all the players (Cachon and Netessine 2004). With subsidy, from Table 2, the retailer uses an arbitrarily small subsidy to induce (*R*, *R*) to be the unique equilibrium. In case (1), both manufacturers become worse off. In case (2), they are indifferent. In case (3), manufacturer 1 prefers (*R*, *R*) whereas manufacturer 2 prefers (*N*, *N*). Thus manufacturer 1 becomes better off and manufacturer 2 becomes worse off.

7. Extensions

7.1. Nonzero Redemption Cost

Here we assume that $c_L \geq 0$ whereas c_H is still very high such that it prohibits a consumer from redeeming rebate.

Proposition 6. *Suppose* $c_L \geq 0$ *and* $0 \leq F_1 \leq F_2$. *There exist two thresholds* c_a *and* c_b *such that:* (*a*) *When* $0 \leq c_L < c_a$, *the rebate equilibrium structure is the same as that in Proposition* 2. (*b*) *When* $c_a \leq c_L < c_b$, *the* *equilibrium outcome is* (R, R) *if* $F_i < T_3$, *and* (N, N) *otherwise.* (*c*) *When* $c_b \le c_L$, (N, N) *is the equilibrium.*

COROLLARY 2. *Suppose* $c_L \ge 0$ *and* $F_1 = F_2 = 0$. (*a*) *When* $0 \le c_L < c_b$, (R, R) *is the equilibrium outcome.* (*b*) *When* $c_b \le c_L$, (N, N) *is the equilibrium outcome.*

Proposition 6 shows that the qualitative structure of the equilibrium rebate decisions for the case of $c_L = 0$ still holds when $c_L \ge 0$, though some equilibrium regions may vanish as c_L becomes higher. When c_L is high enough, it is quite interesting that the asymmetric equilibria (R, N) and (N, R) no longer exist. With the advance of information technology, the fixed cost of a rebate program that relies on online submission could become lower. Corollary 2 shows that even when the fixed costs are zero, the manufacturers do not offer rebate if the redemption cost c_L is too high.

We have conducted a numerical study by solving 92 examples with the following parametric values: $a = 10$, $c_L = 1/20$ or $1/10$ or $2/10$, $\gamma = 1/3$ or $1/2$ or $2/3$ or $4/5$, $m = 1/3$ or $1/2$ or $2/3$, and $\beta = 1/3$ or $1/2$ or $2/3$. (To ensure that the manufacturers sell to both consumer segments, not all the combinations of these parametric values are used.) The examples can be categorized into 3 sets. Sets I (76 examples), II (10 examples) and III (6 examples) correspond respectively to cases (a), (b) and (c) of Proposition 6. In Set I, we observe that the main results of the base model remain valid in all the examples. In particular, the equilibrium rebate decisions are consistent with the results in Propositions 2 and 6. By computing the relevant derivatives, we verify that the equilibrium rebate values are decreasing in γ, and the thresholds T_1 and T_2 are decreasing in γ and m and increasing in β. These results imply that more intense competition, a higher redemption rate or a smaller size of rebate-sensitive segment may induce a manufacturer to stop offering rebate. We also verify that in all the examples, the retailer benefits from more rebate programs and a non-rebate-offering manufacturer is better off when the rival manufacturer stops offering rebate. Moreover, a rebate-offering manufacturer is better off when the rival manufacturer stops offering rebate in 2 examples ($\gamma = 4/5$, $c_L = 1/20$, and either $m = 1/3$ and $\beta = 1/3$, or $m = 1/2$ and $\beta = 2/3$) and is worse off in the other examples. These results are consistent with those in Proposition 3. For instance, more intense competition may hurt the retailer and benefit a manufacturer if it induces the rival manufacturer to stop offering rebate. Similarly, a higher redemption rate or a smaller size of rebate-sensitive segment may benefit a rebate-offering manufacturer. In Set II, (R, R) is the Pareto-optimal equilibrium when the fixed costs of manufacturers' rebate programs are low, and the equilibrium rebate values are decreasing in γ. In Set III, (N, N) is the equilibrium outcome.

7.2. Uniformly Distributed Redemption Cost

Here we assume that a consumer's redemption cost is θc, where $\theta > 1$ and c is uniformly distributed in $[0, c_H]$. The consumer estimates his redemption cost to be c at the time of making purchasing decision. Thus, every consumer underestimates his redemption cost. Given a rebate value r, the slippage effect occurs when the consumer's redemption cost is such that $r \ge c$ and $\theta c > r$. Under these conditions, the consumer is sensitive to rebate but does not redeem it after he makes the purchase.

In the base model with binary redemption cost, the proportion of rebate-sensitive customers (β) is exogenous. In this extension, the proportion of rebate-sensitive customers to manufacturer i is r_i/c_H, which depends on the rebate value. When $1 < \theta \le 2$, we can show analytically that (N, N) is the unique equilibrium for the rebate decisions. When $\theta > 2$, the model is not very tractable and we have conducted a numerical study by solving 26 examples with the following parametric values: $a = 10$, $c_H = 10$, $\theta = 22/10$ or 3 or 4 or 5, and $\gamma = 1/5$ or $1/3$ or $1/2$ or $2/3$ or $4/5$ or $9/10$ or $99/100$. (To ensure that the manufacturers sell to both consumer segments, not all the combinations of these parametric values are used.) We find that most of the main results of the base model remain valid in all these examples. In particular, the equilibrium rebate decisions are consistent with the results in Propositions 2 and 6. By computing the relevant derivatives, we verify that the equilibrium rebate values are decreasing in γ under (R, N), and the thresholds T_1 and T_2 are decreasing in γ (the parameters m and β do not exist in this extension). These results imply that more intense competition may induce a manufacturer to stop offering rebate. We also verify that in all the examples, the retailer benefits from more rebate programs, and a non-rebate-offering manufacturer is better off when the rival stops offering rebate. These results imply that more intense competition may hurt the retailer and benefit a non-rebate-offering manufacturer if it induces the rival to stop offering rebate. This is consistent with the results in Proposition 3. The only main results that differ from the base model are the following. In the base model, the rebate values are decreasing in γ under (R, R). In this model, under (R, R), the rebate values may be increasing or decreasing in γ. The derivatives are positive in 4 examples ($\gamma = 1/5$ and $\theta = 3$ or 4 or 5, and $\gamma = 1/3$ and $\theta = 5$) and negative in the other examples. The equilibrium rebate value is increasing in γ when the positive effect of more demand from the rebate-sensitive segment due to a higher rebate value dominates the other two effects as discussed after Lemma 2 (which is true when competition is less intense and customers are too optimistic about future redemption costs). In the base model, when the rival manufacturer stops offering rebate, a rebate-offering manufacturer may be better or worse off. In all the 26 examples, however, she is always worse off.

8. Conclusion

In this paper, we study manufacturer rebate competition in a supply chain with a common retailer. We identify fixed cost of a rebate program, market size, redemption rate of rebate, proportion of rebate-sensitive consumers and competition intensity as the key performance drivers and characterize how they affect the firms' decisions and their profits. Our analysis reveals some novel and counterintuitive results. For instance, we find that more intense competition induces a manufacturer to lower rebate value or stop offering rebate entirely. When the latter occurs, it hurts the retailer, benefits a non-rebate-offering rival manufacturer, and benefits a rebate-offering rival manufacturer if competition is intense and hurts her otherwise. Similarly, a manufacturer could benefit when market size becomes smaller. A rebate-offering manufacturer could benefit when either redemption rate becomes higher or the proportion of rebate-sensitive consumers becomes smaller, and could be hurt when the rival manufacturer's fixed cost becomes higher. We also find that when the retailer subsidizes the manufacturers to offer rebate programs, it always benefits the retailer but may benefit or hurt the manufacturers. When the retailer wants to induce both manufacturers to offer rebate, he always prefers to subsidize the manufacturer with a higher fixed cost first. Sometimes the other manufacturer will then voluntarily offer rebate even without subsidy.

Our findings offer some interesting managerial insights to practitioners. With rebate competition, a manufacturer may suffer from a seemingly more favorable business environment (e.g., redemption rate becomes lower or market size becomes larger) if it motivates a rival manufacturer to start offering rebate. A retailer should be cautious in taking actions to intensify manufacturer competition because he may get hurt if more intense competition induces some manufacturers to cease offering rebate programs. (Without rebate, a retailer always benefits from more intense manufacturer competition.) Although a retailer always benefits from more manufacturer rebate programs, he may need to subsidize only some, but not all, of the manufacturers to offer rebate and then the other manufacturers will offer rebate voluntarily.

Our model has several limitations. First, we assume that the two manufacturers are heterogeneous only in their fixed costs. When they have different market sizes, our numerical studies show that the manufacturer with a larger market size is more likely to offer rebate. It would be interesting to investigate other types of manufacturer heterogeneity. Second, we assume full information and focus on the slippage effect of rebate. In practice, the retailer may have superior demand information and rebate could offer other benefits such as price discrimination or moving unwanted inventory. Third, sometimes manufacturers offer instant rebate (or coupon) instead of mail-in rebate (or online rebate) in practice. Our current model setup does not account for the benefits of instant rebate and therefore cannot be used to compare it with mail-in rebate. Lastly, our model does not capture the dynamic effect of rebate when it is offered for a limited time. Because all these issues require very different modes of analysis, we leave them for future research.

Acknowledgments

The authors sincerely thank the department editor, M. Eric Johnson, the senior editor, and two anonymous reviewers for their constructive comments and suggestions that help improve the quality of the study. Yunjie Wang, the corresponding author, was supported by Hong Kong PhD Fellowship Scheme. Albert Y. Ha was supported by Wei Lun Foundation and the Research Grants Council of Hong Kong [Project 16505915]. Weixin Shang was supported by Direct Grant of Lingnan University (Hong Kong) [Project DR17A3].

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Supporting Information

Additional supporting information may be found online in the supporting information tab for this article:

Appendix S1: Proofs.