Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Managing Strategic Inventories via Manufacturer-to-Consumer Rebates

Anil Arya, Brian Mittendorf,

MANAGEMENT SCIENCE
Vol. 59, No. 4, April 2013, pp. 813–818
ISSN 0025-1909 (print) | ISSN 1526-5501 (online)

http://dx.doi.org/10.1287/mnsc.1120.1626

Managing Strategic Inventories via Manufacturer-to-Consumer Rebates

Anil Arya, Brian Mittendorf
Fisher College of Business, Ohio State University, Columbus, Ohio 43210
{arya_4@fisher.osu.edu, mittendorf_3@fisher.osu.edu}

Manufacturer-to-consumer rebates are a staple of modern supply chains. Such rebates are typically viewed as a means of price discrimination because of partial redemption by consumers. However, the proliferation of universally redeemed instant rebates suggests the practice may be motivated by additional considerations, an issue we tackle in this paper. Our results demonstrate that consumer rebates can be particularly useful when a supply chain encounters inefficiencies stemming from strategic inventory buildup by retailers. Wary of high wholesale prices, a retailer may hold excess inventory to convey a lower willingness to pay in future interactions and thereby strategically undercut future wholesale prices. As a retaliatory consequence, the manufacturer sets high near-term wholesale prices. The "pull" promotion from consumer rebates encourages more timely retail sales and in doing so undercuts (but does not eliminate) the retailer's strategic inventories. In other words, the introduction of consumer rebates can serve as an enticement for retailers to sell, not just for consumers to buy. Perhaps surprisingly, we find that the manufacturer, retailer, and consumers alike all benefit from the use of rebates, this despite the fact that the manufacturer uses the rebates in self interest and as a strategic weapon.

Key words: inventory; rebates; supply chains
History: Received September 8, 2011; accepted July 15, 2012, by Yossi Aviv, operations management. Published online in *Articles in Advance* October 24, 2012.

1. Introduction

As any consumer can attest, manufacturer rebates represent an important part of the consumer buying experience. The constant presence of manufacturer-to-consumer rebates takes a variety of forms including mail-in certificates, coupons, and instant rebates. In 2011, coupons alone accounted for $4.6 billion in consumer redemptions (NCH Marketing Services 2012), and it is estimated that other postpurchase rebates have soared to $8 billion annually (Parago 2011). The usual explanation for the use of rebates is that not all consumers bother to redeem them, only those who are more price sensitive; this property makes rebates an ideal tool for price discrimination. Yet, the burgeoning use of instant consumer rebates suggests more may be behind the rebate phenomenon.

In this paper, we offer another explanation for rebates. We find that even when rebates can be universally and costlessly redeemed by consumers, they can nonetheless be a useful tool in easing strategic posturing along the supply chain. With rebates, a retailer is less aggressive in carrying inventories, and the manufacturer is less exploitative in setting wholesale prices. To elaborate, we extend the seminal model of Anand et al. (2008), hereafter referred to as AAB, to include the possibility of manufacturer rebates. In AAB, a manufacturer sets periodic wholesale prices, and the retailer responds by procuring goods and setting prices in the retail market over the course of two periods. In an effort to convince the manufacturer to lower its wholesale price in the second period, a retailer may opt to carry additional stocks of inventory after the first period. These extra stocks lower the retailer's marginal benefit of, and thus its willingness to pay for, additional units in the second period. Aware of this retailer tendency to hoard inventories for strategic gain, the manufacturer opts to set a high wholesale price in the first period to avert retailer inventory buildup.

By expanding AAB to include manufacturer rebates, we demonstrate a new benefit of rebates. With time-sensitive consumer rebates, the manufacturer subsidizes initial consumer demand and thereby increases the retailer's opportunity cost of holding inventories. This, in turn, eases pressure on the manufacturer to use a high first-period wholesale price to rein in retailer self-interest. Importantly, optimal consumer rebates encourage a modicum of strategic inventories and thus preserve efficiency gains from strategic inventories but at the same time restrain the retailer's tendency to be excessive in this regard. This feature forms the basis for two key contributions of our analysis: a manufacturer's use of consumer rebates benefits the manufacturer, retailer, and consumers alike, and, given rebates are employed, a retailer's use of inventory for strategic gain also meets the approval of all parties. In effect, although rebates (by the manufacturer) and inventories (by the retailer) are each chosen in self-interest, their joint use results in increased harmony among participants. Although these main results are presented in a parsimonious model of linear pricing arrangements in two-period supply chain relationships, we also extend our analysis to consider (i) more general contractual forms and (ii) a more extended interaction among parties. In each case, we succinctly demonstrate the robustness of the results and present other implications of rebates.

Although the usual view of rebates is that they are offered when there is urgency to sell items, the distinguishing feature herein is that value of rebates is rooted not in the degree of urgency itself but rather in the degree of disconnect in urgency between manufacturers and retailers. Consider the case of grocery store coupons. The usual view of rebates suggests their greatest value may lie in perishable food items for which timely sales are of the essence. In contrast, this paper suggests that perishable items are not ideal for rebates because there is harmony in priorities in that retailers also need to unload the goods quickly. Instead, nonperishable items (e.g., cosmetics, cleaners, medicines) may be particularly apt targets for rebates, because the ability to keep them in inventory means the retailer is less compelled to engage in prompt sales. Consistent with this view, 17 of the top 20 consumer goods coupon categories in 2011 were nonfood items, and even the top food categories were less perishable items such as candy and cereals (NCH Marketing Services 2012). Beyond grocery coupons, many new consumer electronics also come with direct rebates. In this case as well, the use of rebates can be rooted in a disconnect in selling priorities between the manufacturer (who wants a strong start for a new product) and the retailer (who is balancing sales in many categories). If the manufacturer is concerned that its retailer will be slow to push new merchandise, rebates can assuage that fear.[1]

Extant research provides several other complementary explanations for consumer rebates. The notion that consumers with heterogeneous willingness to pay for products also have heterogeneous propensity to redeem rebates means that rebates can be an effective means of price discrimination (e.g., Narasimhan 1984, Gerstner et al. 1994). For this reason, rebates that are not universally redeemed are seen as most appealing to manufacturers (Chen et al. 2007). Even with universal redemption, heterogeneity in consumer redemption costs can justify the use of coupons because they can boost retailer participation in promotions (Gerstner and Hess 1991a, b). Rebates can also increase retailer sales efforts (Taylor 2002) or provide indirect financing for consumers seeking to trade in products (Bruce et al. 2006). When there is fluctuating consumer demand across time, consumer rebates can also be a means of discouraging retailers from buying inputs but rationing sales to consumers to wait for high demand in future periods (Ault et al. 2000); when manufacturers want to encourage additional inventory holding to be prepared for unexpected demand spikes, wholesale price protection serves a related role (Taylor 2001).

In the present analysis, we demonstrate another benefit of consumer rebates, one rooted in coordinating the strategic use of inventories.[2] The model excludes other inventory considerations such as balancing holding and stockout costs, and also excludes traditional justifications for consumer rebates by presuming universal and costless rebate redemption, unconstrained consumer liquidity, and constant consumer demand for products across time. By intentionally excluding such extant tensions in our analysis, we are able to isolate the key upside of consumer rebates that is unique to our analysis—offering manufacturer-to-consumer rebates helps alleviate frictions wrought by excessive accumulation of strategic inventory.

2. Model

We extend the model in AAB to add manufacturer rebates. In each of two periods, a manufacturer produces and sells products to a retailer who, in turn, markets and sells to end consumers. Consumer demand for the product in period i, $i = 1, 2$, is given by $q(P_i) = [a - P_i]/b$, where P_i is the out-of-pocket price paid by consumers. At the start of period 1, the manufacturer sets its unit wholesale price, w_1, for the retailer (the marginal cost to produce is normalized to zero). The manufacturer can also offer initial consumers a rebate of δ per unit for retail purchases. After the manufacturer sets its terms, the retailer procures Q_1 units of the product and sets the retail price, p_1. Given the rebate δ and retail price p_1, the (out-of-pocket) price paid by consumers is $P_1 = p_1 - \delta$, yielding consumer purchases of $q(p_1 - \delta)$. The

[1] Manufacturer rebates are also common in the automotive industry. In that context, our results suggest that rebates can be not just an enticement for consumers to buy, but also an enticement for dealers to sell. That said, the durable nature of automotive goods raises the specter of another issue—rebates may boost sales in the short run but such a boost may poach future demand. Consideration of durable goods and/or secondary markets in analyses of rebates and inventory represents an avenue for future work. We thank the AE for noting this intriguing issue.

[2] The broad theme of strategic supply chain behavior is voluminous and includes theoretical, experimental, and archival studies (e.g., Spengler 1950, Katz 1989, Durham 2000, West 2000, Park and Lee 2002, Lariviere 2008).

manufacturer's rebate expires at the end of the first period; thus the corresponding period 2 variables are as follows: wholesale price is w_2, retailer procurement is Q_2, retail price is p_2, and consumer purchases are $q(p_2)$.[3]

At the end of period 1, the retailer carries forward any excess purchases as inventory; denote the inventory level by I, $I = Q_1 - q(p_1 - \delta)$. These inventoried units, along with new purchases Q_2, are available for sale in period 2. For each unit it carries in its inventory, the retailer incurs a holding cost of h, $h \geq 0$. As in AAB, we assume $a > 4h$, so quantities, prices, and inventory levels derived using the first-order approach are positive. Before we consider the effects of rebates in the setting, an observation confirms the importance of inventory.

Observation 1. (i) In a one-period game, the manufacturer has no reason to offer consumer rebates, and (ii) in a two-period game with just-in-time (JIT; no inventory) operation, the manufacturer has no reason to offer consumer rebates.

Parts (i) and (ii) of the observation each follow from the fact that when inventory holding is moot, offering a rebate of δ in period 1 increases consumer valuation by δ. Because all retail sales coincide with wholesale purchases, the retailer's willingness to pay increases dollar for dollar. Thus, both the retailer and consumers are willing to pay δ more per unit, and the manufacturer must incur an offsetting cost of δ to redeem the rebate, making the net effect zero; that is, the usual view that universally and costlessly redeemed rebates are without merit is true without inventory. We next show the critical role of strategic inventory in creating an endogenous demand for rebates.

3. Results

We first characterize the unique (subgame perfect) equilibrium of the game by employing backward induction. Given I and w_2, the retailer chooses p_2 to maximize its revenue from units sold to customers, net of the incremental cost of providing those units, as in (1):[4]

$$\max_{p_2}\{p_2 q(p_2) - w_2[q(p_2) - I]\}. \tag{1}$$

Solving the first-order condition of (1) yields $p_2(w_2) = (a + w_2)/2$. This and the inventory level I generate the second-period demand for the manufacturer's products, $q(p_2(w_2)) - I$. As a result, the manufacturer sets w_2 to solve

$$\max_{w_2}\{w_2[q(p_2(w_2)) - I]\}. \tag{2}$$

Solving (2) yields $w_2(I) = a/2 - bI$, as in AAB. Intuitively, the retailer can supply to those customers with the highest willingness to pay in period 2 (the top of the downward sloping demand curve) using its own stock, thus reducing its willingness to pay for purchases; the manufacturer is forced to offset retailer hesitance by cutting its wholesale price. Using equilibrium values in (1) and (2), the retailer's and the manufacturer's second-period profits can be written as a function of the inventory level. These values are denoted $\Pi_{R2}(I)$ and $\Pi_{M2}(I)$, respectively. Recognizing its inventory will put downward pressure on the manufacturer's second-period wholesale price, the retailer chooses first-period retail price and inventory level to solve

$$\max_{p_1, I}\{p_1 q(p_1 - \delta) - w_1[q(p_1 - \delta) + I] - hI + \Pi_{R2}(I)\}. \tag{3}$$

Solving (3) yields $p_1(w_1, \delta) = (a + w_1 + \delta)/2$ and $I(w_1, \delta) = (3a - 4w_1 - 4h)/(6b)$. Thus, consumer purchases in period 1 equal $q(p_1(w_1, \delta) - \delta)$; in addition to this amount, the retailer also procures $I(w_1, \delta)$ units. Interestingly, the rebate does not directly affect inventory, only retail quantities sold. It can indirectly affect inventory, however, because it permits the manufacturer to increase wholesale price (which does affect inventory) without reducing retail sales. Given the induced demand in period 1, the manufacturer sets its price and consumer rebate to solve

$$\max_{w_1, \delta}\big\{w_1[q(p_1(w_1, \delta) - \delta) + I(w_1, \delta)] - \delta q(p_1(w_1, \delta) - \delta) + \Pi_{M2}(I(w_1, \delta))\big\}. \tag{4}$$

Solving (4) yields $w_1 = (9a - 4h)/16$ and $\delta = (a - 4h)/16$. The equilibrium values for each variable and the ensuing manufacturer and retailer profits, denoted Π_M^* and Π_R^*, are summarized in Table 1. The table also presents two key benchmarks for comparison, the No Rebates and JIT cases. The No Rebates case refers to the equilibrium in AAB where the manufacturer is unable to issue rebates (i.e., $\delta = 0$). The JIT case refers to the imposition of a just-in-time inventory system under which the retailer only gets inputs it sells (and cannot carry inventory, i.e., $I = 0$).

To get a better feel for the role of rebates, it helps to first compare the JIT and No Rebates benchmarks. With JIT, both inventory and rebates are absent (per Observation 1(ii)). With inventory (but still no rebates), the retailer holds inventory strategically to

[3] The optimality of the expiring rebate is confirmed later.

[4] Technically speaking, the formulation in (1) does not restrict purchases in period 2 to be positive. However, as will be apparent later in the text, the formulation nonetheless yields positive purchases in equilibrium. Adding a restriction that period 2 purchases are positive, i.e., purchases equal $\max\{[q(p_2) - I], 0\}$, does not change the equilibrium.

Table 1 **Impact of Manufacturer-to-Consumer Rebates**

	Rebates	No Rebates	JIT
w_1^*	$\frac{9a}{16}-\frac{h}{4}$	$\frac{9a}{17}-\frac{2h}{17}$	$\frac{a}{2}$
w_2^*	$\frac{3a}{8}+\frac{h}{2}$	$\frac{6a}{17}+\frac{10h}{17}$	$\frac{a}{2}$
δ^*	$\frac{a}{16}-\frac{h}{4}$	0	0
q_1^*	$\frac{a}{4b}$	$\frac{4a}{17b}+\frac{h}{17b}$	$\frac{a}{4b}$
q_2^*	$\frac{5a}{16b}-\frac{h}{4b}$	$\frac{11a}{34b}-\frac{5h}{17b}$	$\frac{a}{4b}$
I^*	$\frac{a}{8b}-\frac{h}{2b}$	$\frac{5a}{34b}-\frac{10h}{17b}$	0
Π_R^*	$\frac{35a^2}{256b}-\frac{3ah}{32b}+\frac{3h^2}{16b}$	$\frac{155a^2}{1{,}156b}-\frac{59ah}{578b}+\frac{76h^2}{289b}$	$\frac{a^2}{8b}$
Π_M^*	$\frac{17a^2}{64b}-\frac{ah}{8b}+\frac{h^2}{4b}$	$\frac{9a^2}{34b}-\frac{2ah}{17b}+\frac{4h^2}{17b}$	$\frac{a^2}{4b}$

reduce the wholesale price in period 2, and, knowing that this effect will boost the retailer's first-period order, the manufacturer increases wholesale price in period 1. Thus, inventories lead to higher (lower) prices in period 1 (2). These features point to two key consequences of strategic inventories. The first effect, the "average pricing effect," reflects that inventories can decrease the prices paid both by the retailer and consumers in period 2 more than they increase them in period 1;[5] that is, the way inventory is carried forward can alleviate double marginalization inherent in supply chains. The second effect, the "pricing variation effect," reflects that inventory leads to intertemporal variability in retail pricing. True, the average price is lower, but that comes from a higher (lower) price in period 1 (2). Because profits are concave in retail price, this represents an inefficiency.

The key question in addressing the effects of rebates is how their use alters these two effects of strategic inventories. As can be gleaned from Table 1, the upside of inventories (the average pricing effect) is greater with consumer rebates. In fact, comparing the net consumer prices under Rebates to the JIT benchmark, rebates allow for a lower second-period price without necessitating any increase in the first-period price. Furthermore, the downside of inventories (the pricing variation effect) is lessened by rebates. When prices are lower (in period 2), they are not as low under rebates, and when prices are high (in period 1), they are not as high under rebates.

In terms of how the gains are split among the parties, a comparison of profits across the regimes reveals that the net effect of rebates is to increase both manufacturer and retailer profit. As for consumers, using the equilibrium values from Table 1 in the expressions for consumer surplus under rebates, $(b/2)([q(p_1-\delta)]^2+[q(p_2)]^2)$, and under no rebates, $(b/2)([q(p_1)]^2+[q(p_2)]^2)$, confirms universal benefits of rebates, as summarized in the following proposition.

Proposition 1. (i) *The manufacturer strictly benefits from offering consumer rebates*, *and* (ii) *the manufacturer's decision to offer rebates also benefits the retailer and consumers*.

To highlight the role of rebates, consider a key comparison in AAB between dynamic wholesale pricing contracts (equivalent to the No Rebates case) and full commitment contracts (equivalent to the JIT case). As in AAB, a comparison of the No Rebates case to the JIT case reveals that dynamic contracts and the strategic use of inventory may or may not be beneficial to the supply chain, depending on the degree of inventory holding costs (Proposition 1 in AAB). However, from Table 1, this equivocal result disappears in the presence of rebates.

Proposition 2. *The use of consumer rebates is preferred to the elimination of inventories* (*JIT*) *by the manufacturer, retailer, and consumers alike.*

3.1. Nonlinear Wholesale Pricing

In the analysis thus far, we have presumed manufacturer pricing takes the standard linear form. While such pricing contracts form the crux of the literature on supply chain coordination, the literature has also stressed that the typical supply chain friction of double marginalization can often be eliminated using more general contractual arrangements (see, e.g., Cachon 2003). Consider the following general (dynamic) pricing arrangement without rebates. In period t, the manufacturer offers a quantity-contingent pricing schedule, $T_t(Q_t)$, where Q_t represents the quantity purchased at the wholesale level, and $T_t(\cdot)$ is the amount transferred to the manufacturer in period t.

In this case, the optimal contract in period 2 is $T_2(Q_2)=0Q_2+(a-2bI)^2/(4b)$, whereas the optimal period 1 contract is $T_1(Q_1)=(2a+h)Q_1/4-bQ_1^2/4+(4a^2-12ah+11h^2)/(16b)$.[6] Under the optimal contract, the inventory carried is $I=(a-2h)/(2b)>0$. Finally, the manufacturer's profit is $a^2/(2b)-h(2a-3h)/(4b)$, whereas the retailer's is 0 (the period 1 fixed fee is set so as to extract the entire surplus). Just as in Theorem 4 of AAB, strategic inventories ensure that the manufacturer cannot achieve first-best profit even with general contracts.

[5] For simplicity, when speaking of intertemporal averages, we will rely on simple averages rather than quantity-weighted averages. That said, in this case, either calculation yields the same conclusion.

[6] This analysis mirrors that of AAB, so the details are omitted for brevity.

If, however, one includes consumer rebates, a more efficient outcome is obtained. In this case, nontrivial rebates serve to restrain the retailer's desire for inventories, which, in turn, permits the general nature of the contracts to eliminate the double marginalization problem. In particular, with rebates the optimal period 2 contract is $T_2(Q_2) = 0Q_2 + (a - 2bI)^2/(4b)$, and the optimal first-period contract is $T_1(Q_1) = (a-h)Q_1 + a^2/(4b)$ and $\delta = a - h$. Under this equilibrium, the manufacturer's profit is $a^2/(2b)$, whereas the retailer's is again 0. In short, with rebates the manufacturer can eliminate strategic inventories and obtain the same profits as an integrated supply chain, and consumers benefit as a result.

Proposition 3. *With nonlinear wholesale prices, consumer rebates yield Pareto gains for $h > 0$.*

Theorems 4 and 6 of AAB together demonstrate that both (i) general contracts and (ii) long-term commitment are necessary to achieve supply chain coordination when strategic inventories are at play. Proposition 3 shows that with consumer rebates, one needs only general contracts to achieve coordination, and long-term commitments are unnecessary. Given the practical difficulties of implementing long-term contracts and the relative ease of offering consumer rebates, the results thus provide some support for the ubiquity of manufacturer-to-consumer rebates and the concomitant rarity of long-term (and nonrenegotiable) wholesale pricing agreements.

3.2. Duration of Rebates

One issue that the two-period model precludes is how long consumer rebates should last. In practice, manufacturers offer rebates that are valid for a limited time, and they have discretion over that time frame. In the setting we study, the presumption that rebates last for one period is without loss of generality, because the alternative of a rebate that lasts both periods serves only to prop up both periods' demands equally, and thus, has no effect on inventory incentives; that is, a limited duration for rebates arises endogenously in the setting. To expand this result to address optimal rebate duration, we revisit the model (again with linear pricing) under three periods of sales. A three-period model not only allows us to address rebate duration but also speaks to the robustness of the results. As with AAB, the desire to carry inventory for strategic reasons and the ensuing repercussions persist under longer time horizons. As we see next, so do the benefits of rebates.

Table 2 provides a summary of the equilibrium outcomes in the three-period case for the three possible rebate duration scenarios: short term (only redeemable in period 1), long term (redeemable in

Table 2 Varying the Duration of Rebates

	Short term	Long term	No rebates/nonexpiring
w_1^*	$\frac{6{,}627a}{11{,}560} - \frac{685h}{1{,}734}$	$\frac{13{,}203a}{22{,}384} - \frac{7{,}121h}{16{,}788}$	$\frac{19{,}881a}{36{,}374} - \frac{13{,}700h}{54{,}561}$
w_2^*	$\frac{141a}{340} + \frac{31h}{51}$	$\frac{9{,}819a}{22{,}384} + \frac{9{,}047h}{16{,}788}$	$\frac{7{,}191a}{18{,}187} + \frac{38{,}846h}{54{,}561}$
w_3^*	$\frac{47a}{170} + \frac{164h}{153}$	$\frac{3{,}273a}{11{,}192} + \frac{25{,}835h}{25{,}182}$	$\frac{4{,}794a}{18{,}187} + \frac{186{,}814h}{163{,}683}$
δ^*	$\frac{847a}{11{,}560} - \frac{685h}{1{,}734}$	$\frac{a}{16} - \frac{h}{4}$	0
q_1^*	$\frac{a}{4b}$	$\frac{2{,}645a}{11{,}192b} + \frac{731h}{8{,}394b}$	$\frac{16{,}493a}{72{,}748b} + \frac{6{,}850h}{54{,}561b}$
q_2^*	$\frac{199a}{680b} - \frac{31h}{102b}$	$\frac{3{,}491a}{11{,}192b} - \frac{3{,}311h}{8{,}394b}$	$\frac{5{,}498a}{18{,}187b} - \frac{19{,}423h}{54{,}561b}$
q_3^*	$\frac{123a}{340b} - \frac{82h}{153b}$	$\frac{7{,}919a}{22{,}384b} - \frac{25{,}835h}{50{,}364b}$	$\frac{13{,}393a}{36{,}374b} - \frac{93{,}407h}{163{,}683b}$
I_1^*	$\frac{13a}{60b} - \frac{37h}{27b}$	$\frac{1{,}309a}{5{,}596b} - \frac{56{,}287h}{37{,}773b}$	$\frac{4{,}604a}{18{,}187b} - \frac{769{,}504h}{491{,}049b}$
I_2^*	$\frac{19a}{85b} - \frac{164h}{153b}$	$\frac{2{,}323a}{11{,}192b} - \frac{25{,}835h}{25{,}182b}$	$\frac{8{,}599a}{36{,}374b} - \frac{186{,}814h}{163{,}683b}$
Π_R^*	$\frac{98{,}843a^2}{462{,}400b} - \frac{33{,}227ah}{104{,}040b} + \frac{88{,}967h^2}{93{,}636b}$	$\frac{106{,}518{,}003a^2}{501{,}043{,}456b} - \frac{57{,}810{,}865ah}{187{,}891{,}296b} + \frac{2{,}555{,}828{,}387h^2}{2{,}536{,}532{,}496b}$	$\frac{1{,}105{,}723{,}317a^2}{5{,}292{,}271{,}504b} - \frac{665{,}767{,}535ah}{1{,}984{,}601{,}814b} + \frac{31{,}542{,}732{,}368h^2}{26{,}792{,}124{,}489b}$
Π_M^*	$\frac{9{,}517a^2}{23{,}120b} - \frac{685ah}{1{,}734b} + \frac{8{,}681h^2}{7{,}803b}$	$\frac{36{,}811a^2}{89{,}536b} - \frac{4{,}323ah}{11{,}192b} + \frac{163{,}505h^2}{151{,}092b}$	$\frac{59{,}643a^2}{145{,}496b} - \frac{6{,}850ah}{18{,}187b} + \frac{521{,}948h^2}{491{,}049b}$

period 1 or period 2), and nonexpiring (which is equivalent to the no rebates solution of AAB). The regularity condition ensuring positive outcomes is $a > 172h/27 \approx 6.37h$.

The next proposition summarizes the key implications that can be derived from Table 2.

Proposition 4. *In a three-period game,* (i) *the manufacturer and retailer each benefit from expiring consumer rebates regardless of their duration, and* (ii) *the manufacturer prefers using a long-duration rebate if and only if h is sufficiently large.*

The proposition confirms that the benefits of rebates persist when interactions occur over a longer horizon. Not only that, but the benefits of rebates are robust to their stated duration—the critical issue is if, not when, rebates expire. In terms of preferred duration for the manufacturer, if holding costs are particularly pronounced, the manufacturer prefers longer-duration rebates. The key difference between the two-period and three-period settings is that in the latter case the retailer has the option to unload inventory carried forward in period 1 in either the near term (in period 2) or the long term (period 3). If holding costs are high, hoarding for the long term is naturally curbed. Thus, with high holding costs, the focus is on short-term hoarding, and the manufacturer finds it best to address that near the end of the game, pointing to a long-duration rebate. In fact, with a long duration, the rebate is $a/16 - h/4$ to limit hoarding prior to the final period, precisely as in the two-period game. In contrast, aggressive short-duration rebates prove valuable to the manufacturer when it needs to curb both near- and long-term strategic inventory posturing. Thus, short-term rebates prove optimal when holding costs are low.

4. Conclusion

This paper demonstrates that when retailers exploit excess inventory as a strategic tool to secure lower wholesale prices, a manufacturer can employ direct-to-consumer rebates to stave off such exploitation. Limited-term consumer rebates serve to subsidize near-term consumer demand, and the resulting "pull" represents a substantial opportunity cost for a retailer seeking to stock excess inventory. Despite arising out of channel conflict, manufacturer-to-consumer rebates benefit the retailer, manufacturers, and consumers alike.

Acknowledgments

The authors thank Tim Baldenius, Francesco Bova, Ron Dye, John Fellingham, Hans Frimor, Doug Schroeder, Stefan Reichelstein, David Williams, department editor Yossi Aviv, an associate editor, and three referees for many helpful comments. Anil Arya gratefully acknowledges assistance from the John J. Gerlach Chair.

References

Anand K, Anupindi R, Bassok Y (2008) Strategic inventories in vertical contracts. *Management Sci.* 54:1792–1804.

Ault R, Beard T, Laband D, Saba R (2000) Rebates, inventories, and intertemporal price discrimination. *Econom. Inquiry* 38:570–578.

Bruce N, Desai P, Staelin R (2006) Enabling the willing: Consumer rebates for durable goods. *Marketing Sci.* 25:350–366.

Cachon GP (2003) Supply chain coordination with contracts. Graves SC, de Kok AG, eds. *Supply Chain Management: Design, Coordination and Operation*, Handbooks in Operations Research and Management Science, Vol. 11 (Elsevier, Amsterdam), 229–340.

Chen X, Li C, Rhee B, Simchi-Levi D (2007) The impact of manufacturer rebates on supply chain profits. *Naval Res. Logist.* 54:667–680.

Durham Y (2000) An experimental examination of double marginalization and vertical relationships. *J. Econom. Behav. Organ.* 42:207–229.

Gerstner E, Hess J (1991a) A theory of channel price promotions. *Amer. Econom. Rev.* 81:872–886.

Gerstner E, Hess J (1991b) Who benefits from large rebates: Manufacturer, retailer, or consumer? *Econom. Lett.* 36:5–8.

Gerstner E, Hess J, Holthausen D (1994) Price discrimination through a distribution channel: Theory and evidence. *Amer. Econom. Rev.* 84:1437–1445.

Katz M (1989) Vertical contractual relations. Schmalensee R, Willig R, eds. *Handbook of Industrial Organization*, Vol. 1 (Elsevier, Amsterdam), 655–721.

Lariviere M (2008) Supply chains. Blume L, Durlauf S, eds. *The New Palgrave Dictionary of Economics*, 2nd ed. (Palgrave Macmillan, Basingstoke, UK), 103–105.

Narasimhan C (1984) A price discrimination theory of coupons. *Marketing Sci.* 3:128–147.

NCH Marketing Services (2012) Coupon facts report. NCH Marketing Services, Deerfield, IL.

Parago (2011) Rebate programs return more than $8 billion to U.S. households. (June 2), http://www.parago.com/2011/06/02/rebate-programs-return-more-than-8-billion-to-us-households/.

Park M, Lee S (2002) Double marginalization problems: Evidence from the Korean fixed-to-mobile service market. *Telecomm. Policy* 26:607–621.

Spengler J (1950) Vertical integration and antitrust policy. *J. Political Econom.* 58:347–352.

Taylor T (2001) Channel coordination under price protection, midlife returns, and end-of-life returns in dynamic markets. *Management Sci.* 47:1220–1234.

Taylor T (2002) Supply chain coordination under channel rebates with sales effort effects. *Management Sci.* 48:992–1007.

West D (2000) Double marginalization and privatization in liquor retailing. *Rev. Indust. Organ.* 16:399–415.