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Creating Win–Win Trade Promotions: Theory and Empirical Analysis of Scan-Back Trade Deals

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Manufacturer trade promotion spending is second only to cost of goods sold as a profit-and-loss item, yet manufacturers often lose money on these deals as a result of forward-buying by retailers. The search for more effective forms of trade promotion and the availability of scanners at cash registers has led to the emergence of a new type of trade deal—the scan-back—that gives retailers a discount on units *sold* during the promotion rather than on units *bought*.

We develop a theory to compare retailer pricing decisions and profitability under scan-back and traditional off-invoice trade deals. We show that, when the terms of the trade deal are identical, retailers prefer off-invoice trade deals and manufacturers prefer scan-backs. Manufacturers can, however, redesign the scan-back to leave the retailer weakly better off and leave themselves strictly better off. Using proprietary data from the beverage category, we conduct an empirical analysis and find that during the promotion period scan-back trade deals, relative to off-invoice deals: (1) Do not cause excess ordering and (2) generate higher retail sales through lower retail prices. Implications for researchers and managers are discussed.

(*Trade Promotion; Scan-Back; Off-Invoice; Forward-Buying; Empirical Analysis*)

1. Introduction

In March 1997, Procter & Gamble announced plans to eliminate 20% of its brands from trade promotion contracts (*Advertising Age* 1997, *Campaign* 1997); other major manufacturers were expected to follow (*Incentive* 1997). This desire to scale back trade promotions is a consequence of the well-known fact that whereas these promotions account for approximately two-thirds of all promotional spending, only 16% of them are profitable.¹ The underlying reasons for the poor performance of trade promotions can be traced to the following three factors: (1) forward-buying by retailers, (2) lack of pass-through to consumers, and (3) diverting. The combination of these three factors

has led some manufacturers to lose faith in the trade promotion system—Durk Jaeger, the former head of Procter & Gamble’s U.S. operations, calls it “impossibly inefficient” and suggests that it is being abused by retailers (*Economist* 1992). In this paper, we show how scan-back trade promotions can reduce or even eliminate these problems.

Although retailers have a variety of marketing tools at their disposal, they make extensive use of promotions² to generate store traffic, increase sales, and match or better the competition. Indeed, it is not uncommon for a supermarket retailer to have up to 3,000 stockkeeping units (SKUs) on a temporary price

¹ See, for example, *Economist* (1989), *Chain Store Age* (1996), and Blattberg and Neslin (1990) for a review.

² We use “trade promotion” to refer to deals that are offered to retailers by manufacturers and “promotion” to denote deals that retailers offer to consumers.

reduction (TPR) at any given time. It is important to realize, however, that more often than not, manufacturers subsidize these promotions. To encourage retailers to promote, manufacturers sell goods at a temporary discount and will often also pay for advertising and temporary displays. This can result in trade promotions that are quite profitable for retailers and very costly for manufacturers (Buzzell et al. 1990). In a recent survey by A. C. Nielsen (*Supermarket Business* 1998a), retailers openly admit that about 13% of the 75 billion dollars spent annually by manufacturers on trade promotions goes straight to their bottom lines. Manufacturers place the figure at closer to 30%. Buzzell et al. (1990) also note that trade promotions impose a severe administrative burden for manufacturers—25% and 30% of salesperson and brand manager time, respectively.

1.1. Trade Promotions: Empirical Analysis and Theory

Trade promotion data are hard to come by, but some empirical analyses have appeared in the literature. Abraham and Lodish (1987a,b) develop an expert system to evaluate trade promotion profitability and, more recently, an automated system (PROMOTION-SCAN) that evaluates short-term sales and provides efficiency diagnostics (Abraham and Lodish 1993). Walters (1989) finds that deeper deals were more likely to gain retailer acceptance, but uncovered no relationship with the manufacturer's rank in the category. Blattberg and Levin (1987) model shipments and retail sales as a function of trade promotion offers and estimated inventory held on hand. They find, consistent with other trade literature, that "...most trade promotions do not pay out" (p. 141) in terms of profitability.³

In an early analytical paper, Lal (1990) provides conditions under which alternating trade deals by national goods manufacturers constitute a Nash equilibrium. The trade deals help fuel consumer promotions, which work to weaken the threat of encroachment by regional brands or private labels.

³ Blattberg and Levin (1989) include a variety of promotion types (e.g., off-invoice, bill-backs, etc.), but scan-backs were not part of their study.

Gerstner and Hess (1991) analyze pure push (trade) and pure pull (consumer) promotions and find that promotions aimed directly at the consumer (e.g., coupons) are preferable for the manufacturer because the cost of getting the retailer to promote to the low reservation price segment is lowered. A combination of trade and consumer promotions is shown to be even more profitable, as it facilitates price discrimination.

Neslin et al. (1995) analyze the retail buying process and derive the influence of trade promotion on the optimal ordering policy of retailers. They show that forward-buying is a barrier that holds back promotion expenditures because it prevents effective use of trade promotions. They also suggest that, as different forms of promotions are introduced to eliminate forward-buying, manufacturers should want to offer steeper promotions. Lal et al. (1996) show that forward-buying by retailers can reduce intermanufacturer competition. The intuition is that forward-buying by retailers lowers the probability that manufacturers will want to offer deals, thereby implicitly softening price competition. They do, however, note that "...the cycle of trade promotion and forward-buying adds considerable costs to the system, ..." (p. 34). In this paper, we focus on the nature of those costs (i.e., how they are generated and their behavior over time), and in particular how an emergent "contractual arrangement"—the scan-back trade deal—can be used to eliminate inventory-induced costs that are *incremental* to the system. We compare the traditional off-invoice trade deal with a new form of deal arrangement: the scan-back. This is important because scan-back trade promotions are becoming increasingly popular (see Ailawadi 2001), but their underlying economics and the associated marketing implications are not well understood.

1.2. Overview and Contribution

We develop a model to understand the impact of scan-back and off-invoice trade deals on retailer cost structure, ordering policy, and price setting, and we show how off-invoice trade promotions encourage forward-buying and introduce the "considerable costs to the system," alluded to by Lal et al. (1996). When the terms of the trade deal (i.e., base price, deal size,

and deal duration) are identical, we show that retailers prefer off-invoice arrangements and manufacturers prefer scan-backs. Furthermore, we show that an appropriate restructuring of the scan-back trade deal can lead the retailer to be indifferent between it and the original off-invoice and leave the manufacturer strictly better off. Finally, we prove that there exists at least one restructuring that produces *no change* in retailer pricing behavior (or consumer purchasing), even though it induces a change in retailer ordering behavior. This means that a comparison of the effectiveness of an off-invoice trade deal and a scan-back deal of this type will be completely unaffected by one's assumptions about consumer behavior.⁴

To obtain these findings, we introduce a variant of a well-known result (see Bulow and Pfleiderer 1983 and Tyagi 1999 for a complementary discussion) and show that optimal constant monopolist prices, set for a fixed interval of time, depend on the average costs in that interval and the price elasticity of demand. Given this, a manufacturer can alter the parameters of the scan-back trade deal to produce a cost stream to the retailer that mimics the *average* cost she faces under an off-invoice trade deal. Although (as noted previously) one specific redesign induces no change in retailer pricing, other redesigns that leave the retailer weakly better off and the manufacturer strictly better off may also change retailer behavior (and therefore consumer response).

Using proprietary data from the beverage category, we conduct an empirical analysis of off-invoice and scan-back trade deals. Data were gathered from a naturally occurring experiment in which a national brand manufacturer offered four different retail chains both scan-back and off-invoice trade deals at different times over the course of a 51-week period. We estimate a system of shipment, sales, and pricing equations and find that during the trade deal period, scan-back trade deals, relative to off-invoice deals:

(1) do not cause excess ordering and (2) generate higher retail sales through lower retail prices.

1.3. Caveats

First, we implicitly assume that retailers are not more efficient than manufacturers are at inventory management: Manufacturers do not encourage forward-buying by retailers because the retailer has a superior inventory-processing infrastructure. The trade literature is consistent with this position, and we do not believe the implicit assumption is especially troublesome.⁵ Second, when setting up our model, we do not allow for demand dynamics. That is, demand in period t is a function of prices in that period only, so there is no consumer stockpiling. As we will show, this assumption is *not* restrictive with respect to our main result. There is always *one* type of redesigned scan-back that produces retailer profits that are identical to those from off-invoice *and* does not cause any change in either retailer pricing or consumer behavior. For other redesigns, it may be important to consider demand dynamics, such as consumer stockpiling and increases in consumption that result from stockpiled inventory. Although a formal analysis of this issue is beyond the scope of this paper, we do investigate it implicitly in our empirical analysis. We also conduct a numerical simulation to explore the basic implications of three generic forms of redesigned scan-back.

1.4. Organization

Section 2 provides institutional background and motivates our analysis of off-invoice versus scan-back trade deals. Section 3 develops the theory of retailer response to push promotions, whereas §4 provides numerical examples to explore three generic forms of redesigned scan-back. Section 5 describes the data and empirical findings, and §6 concludes the paper.

⁴ Several recent papers (e.g., Ailawadi and Neslin 1998, Bell et al. 1999, Sun 2001) suggest that overall consumption may expand in the face of consumer promotions. As we will show later, the presence or absence of such behaviors has no impact on a comparison of off-invoice and at least *one* type of redesigned scan-back. We do, however, explore more general redesigns in §4.

⁵ The authors thank an anonymous reviewer for highlighting this inventory explanation, however; they focus on the well-accepted notion that forward-buying causes retailers to store *excess* inventory and that this is the heart of the inefficiency. Furthermore, some industry experts report that nearly 30% of trade promotion spending is "wasted" because of forward-buying (Edgewood Consulting Group 2001).

2. Background and Motivation

A recent study by Andersen Consulting (*Supermarket Business* 1998b) finds that "...trade promotion is the biggest, most complex and controversial dilemma facing the retail industry today"; yet, despite this, trade promotions continued unabated. Academic researchers have proposed several reasons for this seemingly anomalous behavior: (1) competitive motivation to limit store brands (Lal 1990), (2) the desire to pass inventory down the channel (Blattberg et al. 1981), and (3) the need to encourage retailers to participate in price promotions to low-valuation consumers (e.g., Gerstner and Hess 1991, 1995). The trade literature reports a variety of other motivations, such as the manufacturer's desire to smooth operating performance, lower the retail price without reducing the list price, move inventory, motivate the sales force, maintain distribution, maintain shelf space, and counteract competitors (Struse 1987, p. 150). For most manufacturers, trade promotions are primarily a vehicle for increasing short-term sales, and this assumption is made for the rest of the paper.

2.1. Off-Invoice Trade Deals

Off-invoice deals are straightforward: Manufacturers offer to sell merchandise to retailers at a TPR. The duration of the deal is typically restricted (e.g., two to four weeks), and there is usually no limit on the quantity of goods that can be purchased. The price reduction might be accompanied by secondary clauses covering manufacturer-generated funds for cooperative advertising. Because there are no limits on the quantity that can be purchased, retailers have an opportunity to forward-buy. By engaging in this activity, retailers trade off the cost of carrying excess inventory against the gain from lower purchase prices. Buzzell et al. (1990) estimate that supermarkets across the United States carry from three to four billion dollars of excess inventory and that this is attributable to forward-buying. They also assess the value of diverted merchandise at five billion dollars annually.

In sum, off-invoice trade deals impact the manufacturer-retailer relationship in three ways. First, the incentive structure of the off-invoice deal encourages retailers to be effective *buyers*, rather than

effective *marketers*. Second, manufacturers subsidize more than just the promotion—they end up subsidizing the retailers' daily operations. Third, given the inefficiency and additional costs that forward-buying and diverting introduce to the channel, it is often the case that consumers are negatively affected by low pass-through rates (i.e., less than 100% of the deal value is passed from the manufacturer through to the consumer).

2.2. Scan-Back Trade Deals

The widespread use of scanners means manufacturers can create a different type of trade deal—aptly named "scan-back"—in which they offer to reimburse retailers a certain amount of money for each unit sold during a promotion week. The retailer can start the promotion at any time during the deal window, and the scan-back incentive applies only to the units *sold*, in contrast to the off-invoice deal in which compensation is based on the number of units *purchased*.

There are three key changes that arise from the use of scan-backs. First, it is straightforward to see that there is no gain from forward-buying (see Appendix A.1). If a retailer were to forward-buy, she would not receive the scan-back incentive for the additional units bought because they would be sold after the promotion ends. Second, there is no motivation to divert, because only merchandise sold through the retailer's scanner system is eligible for the promotion.⁶ Third, scan-back trade deals suggest the need for an accurate monitoring system to verify scanner transactions on which deal payments are made. In practice, intermediaries (e.g., www.scannerapplications.com) perform this audit function for a fee.

2.3. Off-Invoice or Scan-Backs?

Which form of push promotion is preferred? By which party? Under what conditions? Before formally addressing these questions, we note that the lack of forward-buying opportunities under scan-back deals

⁶ Note, however, that retailers could still *purchase* diverted merchandise from other retailers and sell through their own system during the scan promotion period, thus benefiting twice. The authors thank Sarah Lonorgan from Sara Lee for pointing this out.

will clearly affect retailers. To make the most of the trade deal, the retailer will have to focus on *marketing* to consumers, rather than on *purchasing* from manufacturers. Furthermore, manufacturers pay only for the promotions and no longer subsidize everyday operations. Hence, at first glance, it appears that a move from off-invoice to scan-back trade deals is a win-lose situation in which manufacturers have the better side of the deal. If this is indeed the case, retailers will not adopt scan-backs. Blattberg et al. (1995, p. G130) foreshadow this concern: "The question that remains unanswered is why the retailer would want to accept scan promotional payments."

3. Theory

Push promotions change the cost structure of the retailer, and therefore the revenue stream of the manufacturer. To focus on differences between off-invoice and scan-backs, we analyze a single retailer interacting with a single manufacturer (e.g., Blattberg et al. 1981, Gerstner and Hess 1995) in the context of push promotions. As noted by Tyagi (1999), an important starting point for understanding pricing decisions in this context is the standard observation in microeconomics: Monopolist prices are a markup of costs, in which the markup factor is determined by the price elasticity of demand. Next, we briefly present a form of this result, then proceed to develop the theory.

3.1. Average Cost and Pricing

It is well known that the optimal price for a monopolist retailer can be characterized by the cost markup expression $C \cdot \epsilon_{p^*} / (1 + \epsilon_{p^*})$, where ϵ_{p^*} is the price elasticity of demand at the optimal price. In our analysis of push promotions, we utilize a related fact: When retailers need to set a constant price over a period of time in which costs vary, the same characterization applies but relies on the *average* unit cost during the period. Consider a retailer who needs to set a constant price over an arbitrary time interval, $[0, \tau]$.⁷ Retailers

price to maximize the following profit function

$$\Pi_{[0, \tau]}^R = \int_0^\tau (P - C_t) \cdot Q_t(P) dt. \quad (3.1)$$

The unit cost, C_t , potentially differs over time during the pricing window, even though the price to the consumer, P , is unchanged. This is because some units sold may have been purchased on promotion, and/or stored before being sold. If we assume that $Q_t(P) = Q(P)$ (i.e., demand at a given price is independent of the time at which the price is offered), then the following modification of the markup rule holds.

LEMMA 1. *If P is chosen to be constant in $[0, \tau]$, then it will depend only on the average unit cost over that interval, \bar{C} , and the price elasticity of demand at the optimal price, ϵ_{p^*} .*

PROOF. Equation (3.1) can be rewritten as

$$\begin{aligned} \Pi_{[0, \tau]}^R &= \int_0^\tau P Q(P) dt - \int_0^\tau C_t Q(P) dt \\ &= \tau P Q(P) - Q(P) \int_0^\tau C_t dt \\ &= \tau P Q(P) - \tau Q(P) \frac{\int_0^\tau C_t dt}{\tau} \\ &= \tau P Q(P) - \tau Q(P) \bar{C}. \end{aligned} \quad (3.2)$$

From Equation (3.2), the first-order condition for profit maximization is

$$\begin{aligned} \frac{\partial \Pi}{\partial P} &= \tau \left[(P - \bar{C}) \frac{\partial Q(P)}{\partial P} + Q(P) \right] = 0 \\ \Rightarrow (P - \bar{C}) &= -Q(P) \frac{\partial P}{\partial Q(P)} \\ &= -\frac{P}{\epsilon_P} \quad \text{since} \quad \epsilon_P = \frac{\partial Q(P)}{\partial P} \frac{P}{Q} \\ \Rightarrow P^* &= \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \bar{C}. \end{aligned} \quad (3.3)$$

Although (3.3) characterizes the general form of the optimal price, particular analytical solutions will depend on the assumed functional form of demand. Consider the commonly used linear demand function, $Q(P) = \alpha - \beta \cdot P$. It is straightforward to show that the optimal price $P^* = \alpha / (2 \cdot \beta) + \bar{C} / 2$ can be rewritten in the form of Equation (3.3).⁸ For these reasons,

⁸ Use $Q^* = (\alpha - \beta \cdot \bar{C}) / 2$, which implies that $\epsilon_{p^*} = (\beta \cdot \bar{C} + \alpha) / (\beta \cdot \bar{C} - \alpha)$ and apply Equation (3.3).

⁷ In many settings, retailers often want to keep the same price in place for several weeks, because of the sheer cost of administering large numbers of price changes (see Levy et al. 1997 for a discussion of menu costs in supermarket retailing).

we make no assumptions about the functional form of demand, other than it is downward sloping. We now characterize retailer behavior and compare optimal response under scan-back and off-invoice deals.⁹

3.2. Push Promotions

In addition to the rationales summarized previously, it is straightforward to formalize why manufacturers offer push deals. As shown in Gerstner and Hess (1991, 1995), manufacturers may want to reach low-valuation customers who might not otherwise be served. Trade deals are needed when the “individual pricing decisions of channel members exclude a consumer segment that would be profitable for the entire channel” (1995, p. 46). One can easily accommodate this in a model by assuming a discontinuous demand function (e.g., a step function), such that the trade deal potentially expands the market. However, in accordance with Tyagi (1999), the manufacturer in our analysis chooses to promote for exogenous reasons, and demand is assumed to be continuous and downward sloping.¹⁰

3.2.1. Single-Period Promotions. Let P , C , and $Q(P)$ denote the retail price, wholesale price, and market demand, respectively. Faced with a wholesale price of C , a profit-maximizing retailer chooses P to maximize $(P - C) \cdot Q(P)$. The first-order condition

$$Q(P) + \partial Q(P)/\partial P \cdot (P - C) = 0, \quad (3.4)$$

is identical to (3.3), so that the form of the optimal price is $P^* = C \cdot \epsilon_{P^*}/(1 + \epsilon_{P^*})$, whereas before, ϵ_{P^*} is the price elasticity of demand at the optimal price. Assuming for the moment that deal price and regular price elasticities are the same (they need not be), a

⁹ Explicit analytical expressions require particular assumed functional forms for demand. Our emphasis on *relative* differences between the two trade deal regimes does not require this, hence we focus on the more general formulation. Complete solutions for the linear and constant elasticity of demand cases are available from the authors.

¹⁰ Note also that the single-period models do not allow for retailers to change prices. If it is optimal for the retailer to promote to reach low-valuation customers, then she will always follow this strategy. Thus, these models cannot accommodate the phenomenon of changes from regular to promoted prices over time.

trade deal of size D leads to the following change in the first-order condition

$$Q(P) + \partial Q(P)/\partial P \cdot [P - (C - D)] = 0, \quad (3.5)$$

so that the solution for the optimal price will follow $P^* = (C - D) \cdot \epsilon_{P^*}/(1 + \epsilon_{P^*})$. The introduction of a trade deal lowers retailer costs from C to $(C - D)$, so that to maximize profits and equate marginal revenues with marginal cost, the retailer will also need to adjust marginal revenues by lowering the price. As we will show, the behavior of retailer costs under off-invoice and scan-back push promotions is critical to the intuition in the paper.

The case of a single period is somewhat trivial in the sense that if the retailer can set only *one* price, then by Lemma 1, it will always be a markup of average unit costs during the period, irrespective of the length of the period. To isolate the differences between the two forms of trade deal, we need to consider the more realistic case in which retailers must respond to both trade deal prices and regular wholesale prices over some finite period of time. That is, there are at least two periods of retail price setting, which may or may not correspond exactly to the duration and timing of trade deals offered by the manufacturer. We formalize these issues in the next section.

3.2.2. Multiperiod Promotions. We create a multiperiod promotion environment by considering an interval of time, $[0, \tau]$, in which the manufacturer offers a push promotion for a shorter period (t_D). This is consistent with how push promotions are offered in practice—manufacturers typically offer push promotions of four weeks (e.g., $t_D = 4$) every quarter (e.g., $\tau = 13$). In the context of this longer time frame, the key difference between off-invoice and scan-back trade promotions lies in the retailer’s incentive to purchase and hold excess inventory.

Consider first a scan-back push promotion, in which the manufacturer offers a push deal of size D for a period of time $t_D < \tau$.¹¹ Furthermore, assume that

¹¹ If $t_D = \tau$, then we have the case just presented in §3.2.1. In §3.2, where forward-buying is allowed for, the forward-buy period is in principle limited by τ . The authors thank a reviewer for this observation.

the demand function $Q(P)$ is known. In this case, the retailer will set prices based on her unit costs, and will find it optimal to set two separate prices in the deal and nondeal periods, 0 to t_D and t_D to τ , respectively. Letting P_P and P_R denote promotion and regular prices, we have

$$\max_{P_P, P_R} \Pi_t^R = \int_0^{t_D} Q(P_P) \cdot [P_P - (C - D)] dt + \int_{t_D}^{\tau} Q(P_R) \cdot [P_R - C] dt. \quad (3.6)$$

Solving the first-order conditions and making use of Lemma 1, we see that the promotion and regular prices have the familiar form: $P_P = (C - D) \cdot \epsilon_{p^*} / (1 + \epsilon_{p^*})$ and $P_R = C \cdot \epsilon_{p^*} / (1 + \epsilon_{p^*})$.¹²

3.3. Push Promotions with Forward-Buying.

We now expand on the previous results by allowing the possibility that retailers forward-buy. This implies that unit cost of goods for the retailer are potentially time dependent.

3.3.1. Inventory Holding Costs and Forward-Buying. In Equation (3.6), we make the simplifying assumption that product moves directly from manufacturer to retailer to consumer. If, however, the retailer forward-buys, then retail unit costs are time dependent (to reflect storage costs). As noted by Blattberg and Levin (1987, p. 129), the length of the forward-buy, which we denote by t_F , is determined by the retailer, *independent* of price setting: "If there is a temporary price reduction, the retailer purchases up to the point where the savings from the promotion are less than the additional holding costs associated with keeping the product in inventory."

Let us define $I(C; t)$ as the function determining the cost of holding one unit of product purchased at a wholesale price of C , for t units of time. Assume that $I(C; t)$ is continuous in t and upward-sloping [i.e., $\partial I(C; t) / \partial t > 0 \forall t > 0$] or, the longer one keeps a unit in inventory, the more expensive it becomes. For consistency, further assume that $I(C; 0) = C$. Then,

when offered a trade deal of size D , the retailer will forward-buy so long as

$$I(C - D; n) < I(C; 0) = C. \quad (3.7)$$

For instance, if we have a holding cost function $I(C; t) = C \cdot \delta^t$, with $\delta > 1$, then the length of the forward-buy period, n , is given by

$$C = (C - D)\delta^n \Rightarrow \delta^n = \frac{C}{C - D} \Rightarrow n = \log_{\delta} \left[\frac{C}{C - D} \right]. \quad (3.8)$$

In this example, δ captures the opportunity cost of money invested in inventory and inventory management infrastructure. That is, $\delta = (1 + d)$, where $d > 0$ is the discount rate. This discount rate is not simply the cost of the money tied up in the inventory, but also captures money invested in warehousing facilities, inventory management, and other peripheral costs associated with forward-buying. This reinforces the notion that purchase of *excess* inventory represents a product-specific investment on the part of the retailer. In practice, d is likely to vary by product category according to product characteristics (storability, bulkiness, etc.).

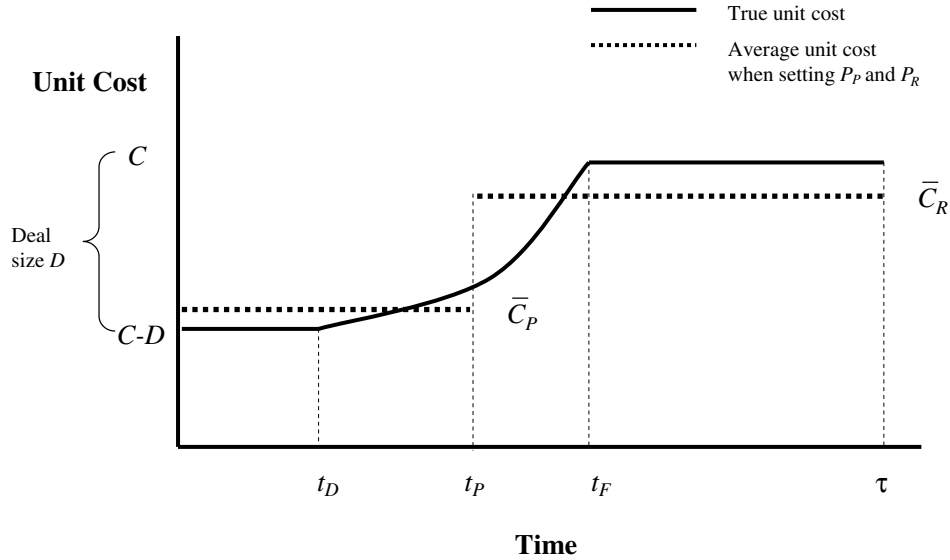
Given the characteristics of $I(\cdot; \cdot)$, we know that the forward-buy period is always strictly positive ($n > 0$), because $\forall D > 0, \exists \eta > 0 : I(C - D; \eta) < I(C; 0) = C$. The point at which the benefits of forward-buying expire, t_F , is therefore equal to $t_D + n$. These relationships are shown in Figure 1.¹³

3.3.2. Multiperiod Promotions with Forward-Buying. We now return to the scenario described in §3.2.2. As before, the manufacturer offers a trade deal of size D for a time period t_D , but this time the retailer is free to forward-buy. As noted previously, the length of the forward-buy period, t_F , is equal to $t_D + n$ and unit costs of all goods are no longer independent of time, but are governed by $I(C; t)$. Furthermore, the retailer now has one additional decision over and above the pricing decisions in Equation (3.6), namely

¹² For ease of exposition, we have once again assumed that deal elasticities and regular price elasticities are the same; i.e., $\epsilon_{P_P} = \epsilon_{P_R} = \epsilon_{p^*}$. We will continue with this assumption for much of the remaining discussion.

¹³ As a practical example, Equation (3.8) implies that if the cost of the product is $C = \$1.00$ and the discount rate is $d = 0.10$ (hence, $\delta = 1.10$), then a retailer who receives a \$0.20 off-invoice trade deal will forward-buy 2.34 weeks of merchandise.

Figure 1 Push Promotions with Forward-Buying



Note. t_D , t_P , t_F , and τ are defined in Equation (3.9).

to determine the length of the promotion, t_P . Indeed, one can intuitively see that unless inventory costs are exorbitant, the cost of some inventoried goods will be sufficiently low to justify a promotional price beyond the deal period set by the manufacturer. Hence, the ability to forward-buy excess inventory affects the cost structure of the retailer and the incentive to promote, such that t_P may not coincide with t_D . Continuing with the previous notation, the retailer's profit function is

$$\begin{aligned} \max_{t_P, P_P, P_R} \Pi_t^R = & \int_0^{t_D} Q(P_P) \cdot [P_P - (C - D)] dt \\ & + \int_{t_D}^{t_P} Q(P_P) \cdot [P_P - I(C - D; t - t_D)] dt \\ & + \int_{t_P}^{t_F} Q(P_R) \cdot [P_R - I(C - D; t - t_D)] dt \\ & + \int_{t_F}^{\tau} Q(P_R) \cdot [P_R - C] dt, \end{aligned} \quad (3.9)$$

where

- t_D = the length of the trade promotion,
- $t_F = t_D + n$, the end of the forward-buy period,
- t_P = the length of the consumer promotion,
- P_P = the promoted price, and
- P_R = the regular price.

Given Equation (3.9), it can be shown (see Appendix A.2) that the optimal prices are

$$P_P^* = \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \bar{C}_P \quad \text{and} \quad (3.10)$$

$$P_R^* = \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \bar{C}_R, \quad (3.11)$$

where \bar{C}_P and \bar{C}_R are the *average* per-unit cost of goods sold at promotion and regular prices, respectively. The precise mathematical definitions are given by the terms in brackets ([]) provided in Equations (A.5) and (A.7). Note that (3.10) and (3.11) conform to the general expression given in Lemma 1, as they should. The average cost during the promotion period (regular price period) is independent of the price or number of units sold during the promotion period (regular price period). The only factors influencing \bar{C}_P are t_P , t_D , and $I(C - D; t)$. For instance, if we use the inventory cost function defined by Equation (3.8), we have

$$P_P^* = \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \frac{1}{t_P} \cdot \left[t_D + \frac{\delta^{t_P - t_D} - 1}{\ln \delta} \right] \cdot (C - D) \quad \text{and} \quad (3.12)$$

$$\begin{aligned} P_R^* = & \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \frac{1}{\tau - t_P} \\ & \cdot \left[(C - D) \cdot \frac{\delta^{t_F - t_D} - \delta^{t_P - t_D}}{\ln \delta} + C(\tau - t_F) \right], \end{aligned} \quad (3.13)$$

where ϵ_{p^*} is the price elasticity of demand at the optimal price (and once again $\epsilon_{P_P} = \epsilon_{P_R} = \epsilon_{p^*}$). Equations (3.12) and (3.13) show that P_P^* and P_R^* only depend on each other through t_p ; so, for a given t_p they are independent and can be derived immediately, regardless of the complexity of the demand curve or cost function, provided these are downward and upward sloping, respectively.

The development so far contains all the building blocks necessary to perform a comparison of the two deal structures. In evaluating the deal types, we rely on the following setup¹⁴:

- The preexistence of an off-invoice deal structure set by the manufacturer, with regular cost C , deal size D , deal length t_D , and total interdeal period τ . These are all exogenously given and could be thought of as arising from a previous optimization process. The retailer has an inventory holding function $I(C; t)$ that includes the cost of product acquisition as previously discussed.

- The retailer responds to the trade deal offers by choosing the optimal values of three decision variables: (1) regular price, P_R ; (2) promotional price, P_P ; and (3) the length of the promotion, t_p . The length of the forward-buy period is predetermined according to C , D , and the inventory holding cost function $I(\cdot; \cdot)$.

- Given the same value of τ , if the manufacturer were able to eliminate forward-buying (and replicate the incentive structure of the scan-back), he would choose new values of the base cost and deal size, such that the retailer's profit is left unchanged.

As we will subsequently show, the final point can be accomplished with only two very parsimonious assumptions: downward-sloping demand and upward-sloping retailer inventory costs.

3.4. Scan-Back Versus Off-Invoice Promotions

Equations (3.6) and (3.9) and their respective solutions highlight several key differences in the effect of scan-back and off-invoice deals on retailer behavior. A retailer maximizing Equation (3.6) purchases only

to fill demand and does not forward-buy. This corresponds to the case of scan-back deals. (Appendix A.1 shows that it is never optimal to forward-buy when offered a scan-back.) Equation (3.9) allows the possibility of forward-buying and reflects retailer response to an off-invoice deal. The results allow us to answer the question posed by Blattberg et al. (1995, p. G130) regarding: "... why the retailer would want to accept scan promotional payments."

3.4.1. Cost and Profit Comparisons. *Average Costs and Profits.* Lemma 1 shows that average unit costs and elasticities are both necessary and sufficient to characterize optimal prices and, therefore, profits. A trade deal is defined by three parameters and is described compactly by the notation {wholesale cost, deal size, deal length}. For a given trade deal offer, the following holds.

PROPOSITION 1. *Given identical off-invoice and scan-back deals (i.e., both are defined by $\{C, D, t_D\}$), average unit costs are lowest during scan-back promotion weeks and highest during scan-back regular price weeks. The off-invoice average unit costs during the promotion period, \bar{C}_P , and regular price period, \bar{C}_R , fall within this range. That is, $I(C - D; 0) < \bar{C}_P < \bar{C}_R < I(C; 0)$.*

PROOF (SEE APPENDIX A.3).

The intuition behind Proposition 1 is that when expanding the promotion period, t_p , past the end of the trade deal offer, t_D , the retailer promotes goods that cost more than $(C - D)$ because of the holding cost associated with forward-bought inventory. This increases the average cost of *all* promoted goods. Conversely, ending the promotion before the forward-bought goods run out (i.e., $t_p < t_F$) reduces the average cost of the nonpromoted goods. These forces work to ensure that average unit costs during the off-invoice promotion, \bar{C}_P , and regular periods, \bar{C}_R , are contained within the lowest possible cost, $(C - D)$, and the highest possible cost, C , that apply during scan-backs.

This knowledge of cost behavior allows us to determine profits. Intuitively, for a given trade deal length and depth, retailers prefer off-invoice and manufacturers prefer scan-backs. To see that retailers prefer off-invoice, consider the case in which the retailer chooses not to promote past the trade deal window

¹⁴ The authors are grateful to an anonymous reviewer for suggesting this line of exposition.

offered by the manufacturer (i.e., $t_p = t_D$). This gives rise to a situation in which $\overline{C_p} = (C - D)$, and therefore off-invoice and scan-back profits will be equivalent during the promotion period. Furthermore, because of forward-buying, we have $\overline{C_R} < C$, so off-invoice profits must be *higher* than scan-back profits during the regular price period. Thus, total off-invoice profits in this *constrained* case with $t_p = t_D$ are higher than total scan-back profits; hence, unconstrained profits in which the retailer is free to set t_p must be at least as high. Conversely, manufacturers prefer scan-backs because they eliminate forward-buying and the associated inventory costs that are indirectly borne by the manufacturer. (We expand on this point shortly.)

An interesting question is: Why do we sometimes see $t_p < t_D$ in practice when our model says that it is suboptimal? In our stylized model, demand is downward sloping in reaction to price, and prices are set using the classic formula derived in Equation (3.3) and described in Lemma 1. In this setting, elasticity is a function of price, and there is a one-to-one relationship between costs and prices. In practice, there are myriad other factors influencing price elasticity. For example, promotions can increase price elasticity, and it is likely the increase in price elasticity is temporary and decreases over time if a promotion is run too long. As we shall subsequently show in Proposition 2, such fluctuations in elasticity do not affect the key result that a mimic scan-back can be designed to dominate the off-invoice deal. If the optimal “real-life” off-invoice calls for $t_p < t_D$, then the mimic scan-back will produce the same result and Propositions 1 and 2 remain intact.

What can the manufacturer do to encourage the retailer to move to scan-backs? As Blattberg et al. (1995) allude, manufacturers need to somehow compensate retailers for the loss of profit opportunities caused by a move to scan-backs. Proposition 2 shows that manufacturers can easily redesign the scan-back in a way that leaves retailers indifferent between it and an off-invoice trade deal, but generates strictly more profits for them.

PROPOSITION 2. *For every off-invoice trade deal, it is possible to design a scan-back trade deal that exactly mimics the off-invoice cost stream, leaving the retailer weakly better off and the manufacturer strictly better off.*

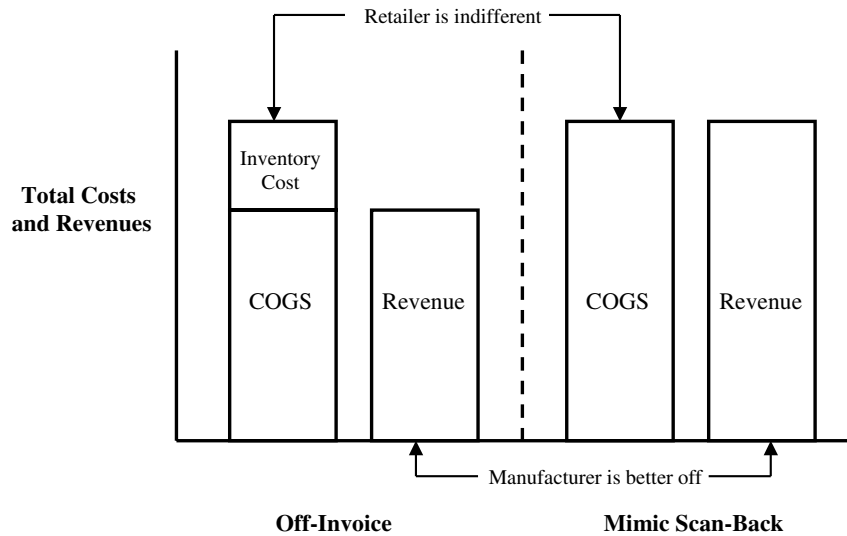
PROOF (SEE APPENDIX A.4).

Proposition 2 holds because money associated with the cost of storing excess inventory does not benefit *either* party. This result is one of the central insights in the paper and although the proof is somewhat lengthy, the intuition follows from the fact that trade promotion deals work by influencing the cost function of the retailer, and per-period profitability is driven by average unit costs (and prices) in the period. Alternative trade promotion schemes that impose the same average costs for the same amount of time, must yield *identical* profits.

The two alternatives we compare are an off-invoice deal and a “redesigned” scan-back, which we will call the “mimic” scan-back. Retailer costs are driven by two factors: cost of goods sold (COGS) and inventory costs. The COGS portion of total cost goes to the manufacturer as revenue, and the inventory costs do not benefit either party. Under an off-invoice trade deal, inventory costs are strictly positive, whereas under a scan-back trade deal they are zero. Hence, for a fixed level of *total* cost (COGS + inventory costs), COGS for the retailer—i.e., *revenues for the manufacturer*—are higher under the redesigned scan-back. These relationships are shown in Figure 2. Although the figure illustrates the situation in which only the manufacturer is strictly better off, it is also possible to create a “win-win” situation for both parties.

Figure 3 illustrates the link between this reappropriation of inventory costs shown in Figure 2 and the original off-invoice unit cost function shown in Figure 1. Compared with a scan-back trade deal, the retailer stands to save the entire trade deal discount for the whole forward-buying period or, Areas II and III in Figure 3. However, only savings in the amount of III are realized, because Area II is spent on inventory management. Unfortunately, the manufacturer bears the full cost (II + III) of the promotion and only derives income from (I). Herein lies the crux of the conflict between retailers and manufacturers. Retailers prefer off-invoice deals because they benefit from forward-buying (III), whereas manufacturers do not like off-invoice because forward-buying is inefficient (it costs them II + III to get the benefits of III). The additional profits for the retailer-generated under off-invoice [i.e., cost savings (III) due to forward-buying]

Figure 2 Off-Invoice Versus Mimic Scan-Back



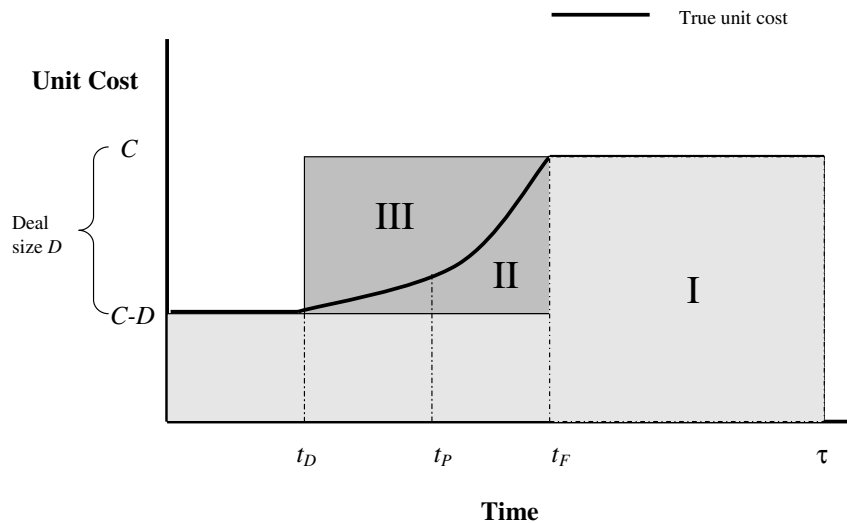
Note. See Proposition 2. COGS = cost of goods sold.

are associated with additional inventory costs (II). This extra expenditure is unfortunately deadweight for the channel, because neither the retailer nor the manufacturer benefit from this extra item. To design an acceptable pay-for-performance deal, the manufacturer needs to get the deadweight out of the system and reappropriate it.

One redesign that achieves this is as follows. A retailer will be indifferent between an off-invoice deal

with parameters $\{C, D, t_D\}$ and a redesigned scan-back deal with parameters $\{\bar{C}_R, D', t_p\}$, where $D' = \bar{C}_R - \bar{C}_p$. Notice that, under this redesigned scan-back, the retailer incurs promotion unit costs of \bar{C}_p for length of time t_p and regular unit costs of \bar{C}_R for $\tau - t_p$, which is *exactly* the same outcome that results when the retailer is offered an off-invoice deal $\{C, D, t_D\}$. (This can be seen from the equivalence of the average costs shown by the dashed lines and true unit costs

Figure 3 How the Retailer Gains from the Off-Invoice Deal



shown by solid line in Figure 1.) It is important to note that this result is invariant to assumptions about consumer demand dynamics, because retailer pricing behavior is *identical* under the two regimes (mimic and off-invoice). Consumers see the same base price, promotion depth, and promotion length in either case: There is no reason to change their behavior.

One might ask what such a redesign means in practice. In this case, the manufacturer gives a smaller deal ($D' < D$), but for a longer time period ($t_p > t_D$), and also lowers his base price ($\bar{C}_R < C$). Although we have shown that this redesign exists, and furthermore that it induces no change whatsoever in consumer behavior, this redesign is by no means unique. The manufacturer could, for example, create another redesign that increases deal size ($D' > D$) but does not change the base price (C) or duration (t_p). We explore this issue in more detail in the next two sections by way of example and empirical analysis.

4. Illustration

We have shown how a manufacturer can redesign his marketing mix to create a scan-back deal that dominates the off-invoice alternative. The change in marketing mix forces him to alter the regular wholesale price, as well as both the length and the depth of the trade promotion. In practice, the manufacturer might be reluctant to induce all these changes at once. For instance, if the manufacturer believes that long promotions erode brand equity, he might want to keep the regular price (C) and the promotion length (t_D) constant and change only the promotion depth (D). Similarly, if the manufacturer believed that very deep promotions might negatively affect the brand, he might want to keep the promotion depth constant and lengthen the promotion.

Changing the promotion depth or length away from that prescribed by the mimic would lead to a change in retail prices. When initiating a nonmimic deal, the manufacturer must therefore take the consumer response function into account. For instance, consumer price sensitivity will dictate how deep price cuts must be to compensate for shorter promotions. Deep price cuts might lead to consumer stockpiling,

which in turn might affect demand during nonpromoted weeks. This means that, if one wants to investigate the options of manufacturers beyond a simple redesigned scan-back ($\{\bar{C}_R, D' = \bar{C}_R - \bar{C}_P, t_p\}$), one cannot rely (as we have done so far) on a general demand function specification; one must be more specific. We will do this in the next sections, where we develop an example based on a constant elasticity demand curve.

4.1. Demand

To illustrate our theory, let us assume that retailers are facing a constant elasticity demand curve [$Q(P) = \alpha_0 P^{\alpha_1}$] and that holding costs are as described in (3.8). These assumptions represent a very stylized framework but are a reasonable facsimile given that we are only trying to illustrate the mechanism behind scan-backs rather than solve a specific real-life trade promotion problem. Table 1 lists six different deal scenarios, including three types of redesigned scan-back [Columns (3) through (6)]. Given the model parameters listed at the bottom of the table, the optimal pricing decision for the retailer, when faced with a wholesale cost of \$5.00 and an elasticity of -3 , is to charge $P = \$7.50$ [per Equation (3.3)]. As shown in Column (1), this will yield weekly sales of 11.85 units, retailer profits of \$296.30, and manufacturer profits of \$197.53 over a 10-week period.

What happens if the manufacturer offers the retailer a \$1.00 trade deal good for one week? If the trade deal is an off-invoice, the retailer will forward-buy. According to Equation (3.8), she will forward-buy 4.57 weeks of merchandise in addition to that needed for the one-week trade deal. She must then decide how deep the promotion will be and for how long it will run given the forward-buying opportunity. Solving (3.9) for our specific demand and cost curves yields (see Appendix §A.5):

$$t_p^* = \log_{\delta} \left[\frac{P_R^{\alpha_1+1} - P_P^{\alpha_1+1}}{(C-D)(P_R^{\alpha_1} - P_P^{\alpha_1})} \right] + 1, \quad (4.1)$$

$$P_P^* = \frac{\alpha_1}{\alpha_1 + 1} \cdot \frac{1}{t_p} \cdot \left[1 + \frac{\delta^{t_p-1} - 1}{\ln \delta} \right] \cdot (C-D), \quad (4.2)$$

$$P_R^* = \frac{\alpha_1}{\alpha_1 + 1} \cdot \frac{1}{\tau - t_p} \cdot \left[(C-D) \cdot \frac{\delta^{t_F-1} - \delta^{t_p-1}}{\ln \delta} + C(\tau - t_F) \right]. \quad (4.3)$$

Table 1 Numerical Illustration of Trade Deals

Deal Parameters	Trade Promotion Deals					
	No Trade Deal	Base Trade Deals		Redesigned Scan-Backs		
		Off-Invoice	Scan-Back	Mimic Scan-Backs	Same Length	Same Depth
	(1)	(2)	(3)	(4)	(5)	(6)
Trade deal						
Retail cost (C)	\$5.00	\$5.00	\$5.00	\$4.92	\$5.00	\$5.00
Deal size (D)	—	\$1.00	\$1.00	\$0.74	\$1.96	\$1.00
Deal length (t_D)	—	1.00	1.00	3.45	1.00	3.04
Forward-buy length (n)	—	4.57	—	—	—	—
Regular weeks						
Regular price (P_R)	\$7.50	\$7.38	\$7.50	\$7.38	\$7.50	\$7.50
Weekly sales	11.85	12.45	11.85	12.45	11.85	11.85
Regular cost (\bar{C}_R)	5.00	4.92	5.00	4.92	5.00	5.00
Promotion weeks						
Promotional price (P_P)	—	\$6.26	\$6.00	\$6.26	\$4.55	\$6.00
Promotional length (t_P)	—	3.45	1.00	3.45	1.00	3.04
Weekly sales	—	20.34	23.15	20.34	52.93	23.15
Promotional cost (\bar{C}_P)	—	4.18	4.00	4.18	3.04	4.00
Total sales	118.52	151.68	129.81	151.68	159.60	152.90
Retailer revenue	\$888.89	\$1,041.06	\$938.89	\$1,041.06	\$1,041.06	\$1,041.06
Retailer profits	\$296.30	\$347.02	\$312.96	\$347.02	\$347.02	\$347.02
Manufacturer revenue	\$592.59	\$661.83	\$625.93	\$674.39	\$694.04	\$694.04
Manufacturer profits	\$197.53	\$156.23	\$193.21	\$168.79	\$162.05	\$184.38

Note. $Q(P) = \alpha^0 P^{\alpha_1}$, $\alpha_0 = 5,000$, $\alpha_1 = -3.00$, $\delta = 1.05$, $\tau = 10.00$, $W = 3.33$.

We solve the equations numerically (the program is available from the authors) to maximize retailer profits for our parameter values. This yields a promotion length, t_p^* , of 3.45 weeks (including the one-week trade deal), and regular and promoted prices of \$7.38 and \$6.26, respectively. This off-invoice promotion in Column (2) shows total sales over the 10-week horizon of 151.68 units, a retailer profit of \$347.02, and a manufacturer profit of \$156.23.

If the trade deal is a scan-back, the retailer will promote for one week only, and set the regular price and promoted price at \$7.50 and \$6.00, respectively [per Equation (3.3)]. This scan-back promotion in Column (3) yields total sales of 129.81 units, a retailer profit of \$312.96, and a manufacturer profit of \$193.21. Hence, as shown in the theoretical development, profits are higher for the retailer under the off-invoice trade deal and higher for the manufacturer under scan-back.

4.2. Redesigned Scan-Backs

In the spirit of Proposition 2, the manufacturer can redesign the scan-back to leave the retailer indifferent between the basic off-invoice trade deal and the new redesigned scan-back. He will do so by mimicking the cost incurred by the retailer in the off-invoice situation. In our case, this means offering a trade deal of \$0.74 for 3.45 weeks at a base price of \$4.92. That is, the optimal promotion length, t_p^* , set by the retailer responding to the off-invoice deal in Column (2) is equal to the deal length set by the manufacturer, t_D , offering the *new* scan-back in Column (4). Looking at Columns (2) and (4), we see the retailer will set the same prices in both cases. Consequently, the retailer will sell the same amount, derive the same revenue and receive the same amount of profit (\$347.02). In short, both consumers and retailers are indifferent between these two trade deals. The manufacturer, in contrast, prefers the mimic scan-back, because with this modified trade deal he nets a profit of \$168.79,

which is higher than the \$156.23 he would make under off-invoice.

What can be done if the manufacturer is reluctant to change the wholesale price, C , and trade deal length, t_D ? The only tool left in his arsenal, short of offering side payments, is to increase the size of the trade deal, D . As shown in Column (5), the manufacturer can still offer a scan-back trade deal that will make the retailer indifferent while increasing his own profits. This is done by increasing the deal from \$1.00 to \$1.96, while keeping the wholesale price at \$5.00 and the trade deal length at one week. Similarly, if the manufacturer wishes to keep the deal depth constant and change only the length of the trade deal, he can offer a \$1.00 trade deal for 3.04 weeks. This deal leaves retailer profits unchanged, but increases manufacturer profits to \$184.38 [see Column (6)].

One must note, however, that the last two solutions in Columns (5) and (6), as opposed to the mimic scan-back in Column (4), yield promotion prices that are different from the promotion prices under the off-invoice. Hence, the ability of the manufacturer to offer a scan-back trade deal that only differs from the off-invoice trade deal in its deal depth or deal length depends on the consumer response function. If consumers are price inelastic, the manufacturer might not be able to offer such deals (the price cut would have to be too deep to yield more profits than those from the off-invoice trade deal), and this may preclude the use of scan-backs in some product categories. Nevertheless, regardless of the consumer demand characteristics, the manufacturer will *always* be able to offer the mimic scan-back ($\{\overline{C}_R, D' = \overline{C}_R - \overline{C}_P, t_P\}$) and leave retailer pricing behavior and consumer response unaffected.

5. Empirical Analysis

We now develop and estimate an econometric model of retail sales and manufacturer shipments. Our approach is similar to Blattberg and Levin (1987), and our data were provided by a cooperating national brand beverage manufacturer who wishes to remain anonymous. Data constitute a “natural experiment” in which scan-back and off-invoice promotions were offered at different times to the same set of retailers.

5.1. Data

Data cover a period of 51 weeks beginning September 1, 1997, for four separate retail chains operating in the northeast, southeast, and western regions of the United States. The data set contains weekly information on the number of cases of product shipped from the manufacturer to the retailers (shipments) and the number of cases sold by retailers to consumers (sales volume). We also have matching market-level data on incremental volume, incremental weeks, and various measures of marketing activity (e.g., percentage of all commodity volume (ACV on a TPR).

During the 51-week period, the manufacturer periodically ran trade promotions of up to five weeks in length. These trade promotions were of one of two types: (1) off-invoice deals and (2) “redesigned” scan-back deals. The deals were always of the same length and offered with equal frequency. The scan-back deal, however, involved a larger per-unit discount.¹⁵ In terms of the notation introduced earlier in the paper, we are comparing an off-invoice deal $\{C, D, t_D\}$ with a scan-back deal $\{C, D' > D, t_D\}$, or we are comparing the two deals illustrated in Columns (2) and (5) of Table 1.

Initial inspection of the data indicates a wide disparity among the retailers in terms of quantity of product ordered and sold, the extent to which retailers are selling out of inventory, and the way in which they support the product. (Table 2 provides the summary statistics.) The larger California chain charges the highest prices but also puts considerably more effort into merchandising the product, featuring it in approximately 20% of the weeks and always featuring it when the product is discounted. Conversely, the smaller retailer is more likely to promote the product with just a TPR. In the Northeast, price promotions are unlikely to be accompanied by other forms of support. This is even more pronounced in the Southeast, where nonprice marketing activities are almost nonexistent. The discrepancy between cases shipped (from manufacturer to retailer) and cases sold (from retailer

¹⁵ Although we are not able to disclose the exact terms of the deal, consistent with the theory and numerical illustration advanced in the paper, this type of redesign is required for retailers to implement the scan-back trade deal.

Table 2 Summary Statistics for the Retailers

Variable	Retailer			
	Northeast	California 1	California 2	Southeast
Units sold	201,313	25,426	258,803	63,697
Units shipped	198,664	5,838	319,404	55,280
Average sold	3,947	499	5,075	1,249
Average shipped	3,895	114	6,263	1,084
Marketing activity				
<i>Prices per 48 ounces</i>				
Average promo price	2.44	2.28	3.14	1.99
Average regular price	2.48	2.43	3.19	2.59
<i>All Commodity Volume</i>				
% on Display	1.0	0.5	2.3	0.2
% on Feature	7.7	7.0	20.7	1.9
% on Feature & display	5.9	0.2	11.4	0.0
% on TPR	13.9	9.9	0.3	17.5

Note. TPR = temporary price reduction.

to consumer) is most pronounced in California. The larger retailer orders almost 60,000 more cases than it sells.

5.2. Hypotheses and Model

The empirical analysis is only suggestive, because we do not attempt to directly estimate parameters of the theoretical model. That is, we do not explicitly test the key theoretical result that scan-backs pareto dominate off-invoice deals. Nevertheless, if the theory and accompanying numerical illustration hold true, then we should expect to find support for the following two hypotheses:

H1. *Retail demand should be higher under the redesigned scan-back promotion as retailers respond to the greater trade deal depth and because their compensation is based on units sold.*

H2. *Due to forward-buying, retailer shipments will be greater under off-invoice than under scan-back trade deals (see also Appendix A.1).*

Over the long run, the amount of product shipped from a manufacturer to a particular retailer should equal the amount that retailer sells. Although this seems reasonable at its face, Table 2 would suggest that these two quantities are not always equal—quite possibly because of diverting. Given this, we do not estimate an endogenous system in which quantities

shipped and sold are identical [i.e., the equilibrium condition imposed is $Q(\text{SHIP}) = Q(\text{SALES}) = Q$]. We estimate the parameters of a three-equation system (shipments, sales, and prices) by generalized least squares.

Following previous empirical research on trade promotion (e.g., Abraham and Lodish 1993; Blattberg and Levin 1987), we posit that shipments ordered will be a function of existing levels of inventory, the type of deal offered, and the recency of previous deals. We control for possible expansion or contraction in the market through the use of a time trend. Moreover, we take account of the typical four-week buying and promotion cycle by smoothing weekly sales into a four-week moving average. We estimate the following semilog specification for shipments as part of our full system¹⁶

$$\begin{aligned} \ln(\text{SHIP})_t = & \beta_0 + \beta_1 \cdot \text{OI}_t + \beta_2 \cdot \text{SB}_t + \beta_3 \cdot \text{INV}_t \\ & + \beta_4 \cdot t + \beta_5 \cdot \text{OIEND}_t \\ & + \beta_6 \cdot \text{SBEND}_t + \nu_{1t} \end{aligned} \quad (5.1)$$

¹⁶ We also estimated linear models and log-log models; however, the semilog model is preferred on the basis of fit. All three model formulations lead to the same qualitative conclusions. We also included a “last week of deal” dummy variable, but did not obtain any statistically significant coefficients.

where

$SHIP_t$ = week t shipments to the retailer,

OI_t = 1 if retailer was offered an off-invoice deal in week t , 0 otherwise,

SB_t = 1 if retailer was offered a scan-back deal in week t , 0 otherwise,

INV_t = estimated retailer inventory on hand at the beginning of week t ,

$OIEND_t$ = 1 if the off-invoice deal expired for retailer at $t - 1$, 0 otherwise, and

$SBEND_t$ = 1 if the scan-back deal expired for retailer at $t - 1$, 0 otherwise.

Retail sales are modeled as a function of retail prices and marketing activity. The effect of deal type on retail sales, however, occurs *indirectly* via the effect on prices. That is, we do not include deal type as a covariate in the sales equation as the type of deal offered to the retailer by the manufacturer is not observable to the end consumers. We also control for retailer inventory levels and, as with shipments, we take account of the typical four-week buying and promotion cycle by smoothing weekly sales into a four-week moving average and estimate the following model

$$\ln(SA)_t = \theta_0 + \theta_1 \cdot \ln(PRICE_t) + \theta_2 \cdot \ln(FEAT/DISP_t) + \theta_3 INV_t + \nu_{2t}. \quad (5.2)$$

$$PRICE_t = \delta_0 + \delta_1 \cdot OI_t + \delta_2 \cdot SB_t + \delta_3 PRICE_{t-1} + \nu_{3t}, \quad (5.3)$$

where

SA_t = week t sales,

$PRICE_t$ = week t retail price,

$FEAT/DISP_t$ = percentage of ACV on feature/display in week t ,

INV_t = estimated retailer inventory on hand at the beginning of week t ,

OI_t = 1 if retailer was offered an off-invoice deal in week t , 0 otherwise, and

SB_t = 1 if retailer was offered a scan-back deal in week t , 0 otherwise.

5.2.1. H1: Trade Promotions and Sales. We anticipate a negative effect for price ($\theta_1 < 1$) and positive

effects for feature/display and levels of inventory on hand ($\theta_2 > 0$, $\theta_3 > 0$). Both types of trade deals should lead the retailer to lower the retail price (i.e., $\delta_1 < 0$ and $\delta_2 < 0$). If scan-back trade deals engender greater consumer demand, it should also be the case that $\delta_2 < \delta_1$.

The parameter estimates for Equations (5.2) and (5.3) are given in Table 3. For the sales equation, all parameters have the anticipated sign. The price coefficients (θ_1) are negative as expected; however, in the California 1 market, the estimate is not significantly different from one (or zero for that matter). This empirical result, although not unusual per se (see Hoch et al. 1994), is at odds with the theory that implies that the price elasticity be negative and greater than one in magnitude for prices to be positive. The other three estimates do not suffer from this problem.

The indirect effect of deal type on retail demand can be seen through the results for the pricing equation. Off-invoice deals appear to have a rather negligible effect on retail prices, yet scan-back trade deals lead to a significant lowering in three of the four markets. Moreover, we find that $\delta_2 < \delta_1$ ($p < 0.05$ in all cases). We find support for H1: The scan-back trade deal leads to greater retail sales because it generates a bigger reduction in the retail price to consumers.

5.2.2. H2: Trade Promotions and Shipments. We expect retailers to increase orders substantially during off-invoice periods (i.e., $\beta_1 > 0$). Furthermore, we expect to see a "trough" in ordering after the expiration of the off-invoice deal (i.e., $\beta_5 < 0$). The inventory effect should be negative (i.e., $\beta_3 < 0$), because higher levels of inventory on hand should reduce the need for additional shipments. As with Blattberg and Levin (1987), the level of inventory on hand, INV_t , needs to be estimated from the data because it is not provided directly. We compute inventory in a given week by assuming starting inventories were equal to eight weeks of average weekly shipments, and current inventories increment with previous shipments and decrease with sales.¹⁷

¹⁷ This eight-week determination was made in consultation with the data supplier. One should note, however, that except for the intercept, the regression parameters do not change with changes in this initial condition.

Table 3 Retailer-Specific Models for Sales and Prices

Variables	Northeast (System-Weighted $R^2 = 0.204$)			California 1 (System-Weighted $R^2 = 0.718$)		
	Coefficient	Std. Error	Pr > t	Coefficient	Std. Error	Pr > t
Sales						
Intercept (θ_0)	8.747	0.399	< 0.0001	4.893	0.557	< 0.0001
Price (θ_1)	-1.410	0.619	0.028	-0.873	0.681	0.211
Feature/display (θ_2)	0.007	0.003	0.045	0.225	0.067	0.003
Inventory (θ_3)	0.000023	0.000012	0.070	0.000210	0.000029	< 0.0001
Prices						
Intercept	2.520	0.388	0.000	2.404	0.384	0.000
Off-Invoice (δ_1)	-0.043	0.088	0.630	-0.155	0.092	0.105
Scan-Back (δ_2)	-0.227	0.100	0.028	-0.668	0.115	0.000
Lagged prices (δ_3)	-0.005	0.156	0.974	0.213	0.128	0.107
Variables	California 2 (System-Weighted $R^2 = 0.356$)			Southeast (System-Weighted $R^2 = 0.589$)		
	Coefficient	Std. Error	Pr > t	Coefficient	Std. Error	Pr > t
Sales						
Intercept (θ_0)	21.266	4.293	< 0.0001	6.683	0.095	< 0.0001
Price (θ_1)	-14.887	4.963	0.005	-1.615	0.069	0.023
Feature/display (θ_2)	0.025	0.005	< 0.0001	0.001	0.010	0.102
Inventory (θ_3)	0.000004	0.000005	0.687	0.0000105	0.000002	< 0.0001
Prices						
Intercept	2.193	0.431	0.000	0.521	0.235	0.032
Off-Invoice (δ_1)	-0.037	0.026	0.166	-0.074	0.048	0.133
Scan-Back (δ_2)	-0.058	0.022	0.013	-0.089	0.063	0.166
Lagged prices (δ_3)	0.316	0.135	0.024	0.811	0.091	0.000

Table 4 shows the results from estimating Equation (5.1) for each retailer. Of particular interest is that all retailers order significantly more than baseline shipments when offered an off-invoice deal ($\beta_1 > 0$, $p < 0.05$; $p < 0.10$ for the Northeast retailer); yet, when scan-back trade deals are offered, there are no statistically significant increases in order sizes. In our theoretical model, this is because under scan-backs, retailers order to meet demand exactly. In practice, we can speculate that retailers are making the additional sales from existing inventory; however, it would be nice to have additional data to verify this. Unfortunately, we are somewhat constrained by the fact that we cannot fully account for all product inflows and outflows for a particular retailer. Nevertheless, our data suggest retailers do not buy *excess* inventory when offered scan-backs, and in all regions except California 1, the off-invoice lift exceeds that of the scan-back ($\beta_1 > \beta_2$) as expected. H2 has some support, although it is not as strong as we would hope,

because we do not see significant end-of-deal effects (although all β_5 estimates are correctly signed).¹⁸

5.2.3. Shipments, Sales, and Prices. The descriptive analysis in Table 2 and the parameter estimates in Tables 3 and 4 paint an interesting picture of how the different trade promotion regimes influence retailer behavior. The Northeast retailer has annual sales and shipments that are virtually identical to each other (Table 2). This retailer appears to order more in response to the off-invoice deal (Table 4), but does not experience a corresponding increase in retail sales under this regime, presumably due to the very small reduction in the retail price to consumers (Table 3). This is consistent with forward-buying. The findings

¹⁸ We have interpreted the fact that $\beta_1 > \beta_2 = 0$ as being sufficient for evidence of forward-buying (i.e., there is loading up during the off-invoice deal period but not during the scan-back period). A more stringent test would *also* require that $\beta_5 < 0$, whereas $\beta_6 = 0$ (i.e., there is a shipment “trough” at the end of the off-invoice deal but not at the end of the scan-back deal). The authors thank the area editor for this observation.

Table 4 Retailer-Specific Models for Shipments

Variables	Northeast (System-Weighted $R^2 = 0.204$)			California 1 (System-Weighted $R^2 = 0.718$)		
	Coefficient	Std. Error	Pr > t	Coefficient	Std. Error	Pr > t
Intercept (β_0)	7.720	0.713	< 0.0001	7.207	0.554	< 0.0001
Off-Invoice (β_1)	1.319	0.693	0.065	1.180	0.548	0.037
Scan-Back (β_2)	0.110	0.649	0.866	2.207	1.532	0.102
Inventory (β_3)	-0.000020	0.000037	0.608	0.000063	0.000100	0.670
Trend (β_4)	0.010	0.009	0.324	0.001	0.013	0.910
Post Off-Invoice (β_5)	-1.246	0.829	0.141	-1.320	0.704	0.073
Post Scan-Back (β_6)	-1.097	0.895	0.228	-2.421	1.290	0.073
	California 2 (System-Weighted $R^2 = 0.356$)			Southeast (System-Weighted $R^2 = 0.589$)		
	Coefficient	Std. Error	Pr > t	Coefficient	Std. Error	Pr > t
Intercept (β_0)	9.377	0.980	< 0.0001	4.235	1.557	0.010
Off-Invoice (β_1)	1.393	0.616	0.030	1.424	0.617	0.026
Scan-Back (β_2)	-0.288	0.517	0.581	-0.178	0.546	0.746
Inventory (β_3)	-0.000400	0.000016	0.014	-0.000326	0.000200	0.111
Trend (β_4)	0.037	0.014	0.013	0.034	0.013	0.012
Post Off-Invoice (β_5)	-0.941	0.747	0.215	-1.215	0.782	0.128
Post Scan-Back (β_6)	-0.851	0.559	0.136	-1.239	0.737	0.101

for the first California retailer are somewhat more difficult to interpret, given the weak results in the shipment equation and an implied price elasticity that is inconsistent with the underlying theory.

The second California retailer exhibits a worrying pattern that suggests diverting. Table 2 shows that annual units shipped to this retailer exceed 319,000 cases, yet sales are just under 259,000. The Southeast retailer loads up under off-invoice but does not appear to reduce retail prices to a significant degree under either regime. In sum, the empirical findings imply that the scan-back trade deal is likely to yield significant benefits for the manufacturer. Retailers are more likely to lower retail prices and consequently sell more during scan-back trade promotion periods, and they do not appear to forward buy. Although we do not estimate the parameters of our theoretical model directly, these collective patterns are certainly consistent with the results derived from our theory and from the numerical illustration.

6. Discussion and Conclusion

Finding ways to create effective and efficient trade promotion practices is perhaps the most critical issue in retail management today. In this study, we develop theory, numerical examples, and empirical analysis

to highlight important differences between scan-back and off-invoice trade deals. Four substantive findings emerge from this research:

1. For a given set of deal parameters (regular price, deal size, and deal duration), the retailer always prefers an off-invoice deal (because of the benefits from forward-buying), whereas the manufacturer always prefers a scan-back. It is very interesting to note that this theoretical result is consistent with recent empirical work by Murry and Heide (1998). They use a conjoint design and find that performance-based incentives (i.e., when retailers are compensated on the basis of product sold) reduce the likelihood that retailers participate in manufacturer-initiated display programs. The negative part-worth for performance-based deals in their study is a nice corroboration of our theory that with "everything else equal," retailers prefer off-invoice deals.

2. Manufacturers can redesign the scan-back to replicate the retailer profits generated by the off-invoice deal. The redesign makes the retailer indifferent between the off-invoice and the scan-back and makes the manufacturer strictly better off. This says that manufacturers can create incentive-compatible scan-back trade deals and reap some of the benefits listed below and validated in our empirical analysis. Moreover, under the mimic scan-back, $\{\bar{C}_R, D' =$

$\overline{C}_R - \overline{C}_P, t_p\}$, in which the manufacturer changes the regular price as well as deal length and duration, the retail prices to consumers are *identical* to those from an off-invoice deal. The manufacturer is strictly better off, yet consumers do not see any change.

3. Off-invoice trade deals lead retailers to purchase excess inventory during the promotion, but scan-back deals do not. For a redesigned scan-back in which the deal length is the same as off-invoice, but the deal depth is increased, consumer demand increases. This is because the retailer has no ability to pocket the scan-back trade deal. Empirical analysis of data from four retailer chains operating in three different regions of the United States support this view. Off-invoice, relative to scan-back deals, either led to higher orders without a corresponding increase in sales, or scan-backs led to greater retail sales without significant increases in promotion-period ordering, or both.

4. The combination of larger orders by one retailer and lower sales to consumers during off-invoice trade promotions is suggestive of diverting and highlights another problem with the traditional form of trade deal.¹⁹

These substantive findings generate several implications for managers and for future work on trade promotion. In particular,

- Under scan-back deals, both retailers and manufacturers benefit from a shift in focus by the retailer (from purchasing to marketing). The scan-back is more consistent with a retailer's core function in the channel.

- It is tempting to think that for manufacturers to design a win-win scan-back trade deal, they need close ties with retailers. Practically speaking, they only require access to the average unit costs during promotion and nonpromotion periods under off-invoice trade deals, \overline{C}_P and \overline{C}_R , respectively. These numbers are potentially estimable without any help from the retailer. (Inventory costs can be estimated from the number of weeks of forward-buying that result from off-invoice deals, and t_p and τ can be

determined by observation.) Not only is it possible to estimate these key parameters but also when shifting to scan-back, the modeling effort for profit optimization and research purposes is greatly simplified (see Silva-Risso et al. 1999).

- There may still be some instances in which manufacturers should want to use off-invoice deals (e.g., overproduction and seasonality may drive a need to move inventory). Thus, there may instances in which the manufacturer wishes to use a mix of trade deal types.²⁰

Several issues remain for future research:

- The complex issue of diverting has not been analyzed in this paper. Further investigations of trade deal practices could include diverting and a thorough analysis of the production implications of variable retailer demand under different regimes.

- Enforcement of scan-back agreements remains an important topic. Indeed, some manufacturers report that, even with scanner technology, data accuracy is a problem. This has prompted both Information Resources, Inc. and Nielsen to set up departments that deal with scan-back promotions and act as an independent auditor of sales. Specialist companies dealing only in the management of scan-back promotions (e.g., Scanner Applications, Inc.) have also appeared. In this paper, we implicitly assume that such audit costs are zero. Provided that audit costs are small relative to deadweight inventory costs, the qualitative conclusions of this research will be unaffected.

- While we prove that our mimic scan-back result is unaffected by consumer dynamics, it would nevertheless be interesting to study how consumer-level stockpiling in response to promotions might affect the viability of other kinds of scan-back. This is especially important given that recent work in consumer promotions suggests that such effects might be more prevalent than previously thought (e.g., Aliwadi and Neslin 1998, Sun 2001).

- As with other papers on trade promotion (e.g., Blattberg et al. 1981, Gerstner and Hess 1995), we have made no explicit attempt to model competitive forces at either the manufacturer or retailer level. It could be worthwhile to investigate scenarios in

¹⁹ When manufacturers give off-invoice deals, it is quite likely that retailer-specific orders and sales will be out of balance as forward-bought merchandise gets diverted. Our data show some evidence of this.

²⁰ The authors thank an anonymous reviewer for this observation.

which competing manufacturers offer different types of trade deals. That said, because the mimic scan-back induces the same best-response function as off-invoice, adding retailer-level competition would not change anything. Adding manufacturer competition would give more power to retailers and consumers. In this case, the money saved by the manufacturer who uses the mimic scan-back constitutes a cost advantage that he would use (by passing it on to the retailer) to have the upper hand vis-à-vis the other manufacturers. This would make scan-backs even more attractive.

- We have not allowed the retailer to “pocket the deal.” We have assumed a frictionless world in which retailers can change prices at will, and, in such a world, retailers will always respond to a trade promotion with some level of price decrease. In practice, menu and other fixed costs (see Levy et al. 1997) may be such that the retailer prefers to pocket the deal.²¹ This begs the question: How can one mimic a promotion that is never run? The short answer is that one can offer a lump-sum payment in lieu of the trade deal.

- Channel relationships are often plagued by double marginalization (e.g., Tirole 1990), and scan-backs do not eliminate this problem (as a pure profit-sharing arrangement would). As we have shown, however, off-invoice deals and mimic scan-back deals lead to the same retail-pricing outcomes, so the issue is not especially relevant for that this case. When nonmimic alternatives are used [e.g., see Columns (5) and (6) of Table 2], it is the case that regular prices are higher for these scan-back regimes.

This paper offers perhaps the first detailed comparison of traditional off-invoice and scan-back trade

deals. We hope the results will be useful to practitioners who work in the complex world of trade promotion and to researchers who are interested in the fundamentals of retailer/manufacturer relationships.

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Appendix

A.1. No Excess Inventory Under Scan-Backs

When the scan-back trade deal is in force, the retailer faces a unit cost of C and receives a deal of size D for each unit sold. As defined in §3.3.1, the unit cost of inventory $I(C-D; 0) = C-D$ and $I(C-D; x) > C-D$, where $x > 0$. Define the order quantity for period t as O_t and the inventory on hand at period t as INV_t . Because there is no uncertainty in demand, working from the initial condition (inventory = I_0), we have

$$I_0 = 0 \\ I(C-D; 0) = C-D$$

which implies

$$\frac{O_t \cdot (C-D) + INV_{t-1} \cdot I(C-D; 1)}{O_t + INV_{t-1}} > C-D \text{ if } INV_{t-1} > 0 \\ \text{and } I(C-D; 1) > C-D. \quad (\text{A.1})$$

Therefore, $INV_{t-1} = 0$ is optimal $\forall t$ if there is an inventory carrying cost and a scan-back trade deal is offered.

A.2. Multiperiod Promotions with Forward-Buying

General Case. The first-order conditions for the general problem given in Equation (3.9) are

$$\frac{\partial \Pi}{\partial t_P} = Q(P_P) \cdot P_P - Q(P_R) \cdot P_R + Q(P_R) \cdot I(C-D; t_P - t_D) - Q(P_P) \cdot I(C-D; t_P - t_D) = 0 \quad (\text{A.2})$$

²¹ Mulhern and Leone's (1991) study of implicit price bundling offers additional insight here. They show that total retail profits from a promotion on a given brand come from three sources: the impact on the promoted brand, substitution effects (consumers switching from other brands), and complementary effects (sales in related categories). In their examples the retailer always passes on some fraction of the deal (see Figures 4 and 5, pp. 73–74); however, if the promotion effects net to be negative, it may be profitable for the retailer to pocket the entire deal. The authors thank the area editor for this observation.

$$\frac{\partial \Pi}{\partial P_p} = \left[\frac{\partial Q(P_p)}{\partial P_p} \cdot P_p + Q(P_p) \right] \cdot t_p - \frac{\partial Q(P_p)}{\partial P_p} \cdot \left[\int_0^{t_D} I(C-D; t-t_D) dt + \int_{t_D}^{t_p} I(C-D; t-t_D) dt \right] = 0 \quad (\text{A.3})$$

$$\frac{\partial \Pi}{\partial P_R} = \left[\frac{\partial Q(P_R)}{\partial P_R} \cdot P_R + Q(P_R) \right] \cdot (\tau - t_p) - \frac{\partial Q(P_R)}{\partial P_R} \cdot \left[\int_{t_p}^{t_F} I(C-D; t-t_D) dt + \int_{t_F}^{\tau} I(C; 0) dt \right] = 0. \quad (\text{A.4})$$

Beginning with the promotion price, P_p , rearrange (A.3) as follows

$$\begin{aligned} & \left[\frac{\partial Q(P_p)}{\partial P_p} \cdot P_p + Q(P_p) \right] \cdot t_p \\ &= \frac{\partial Q(P_p)}{\partial P_p} \cdot \left[\int_0^{t_D} I(C-D; 0) dt + \int_{t_D}^{t_p} I(C-D; t-t_D) dt \right] \\ &\Rightarrow P_p^* = \frac{\frac{\partial Q(P_p)}{\partial P_p}}{\left[\frac{\partial Q(P_p)}{\partial P_p} + \frac{Q(P_p)}{P_p} \right]} \cdot \frac{1}{t_p} \\ &\quad \cdot \left[\int_0^{t_D} I(C-D; 0) dt + \int_{t_D}^{t_p} I(C-D; t-t_D) dt \right] \\ &= \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \left\{ \frac{t_D \int_0^{t_D} I(C-D; 0) dt}{t_D} + \frac{(t_p - t_D) \int_{t_D}^{t_p} I(C-D; 0) dt}{(t_p - t_D)} \right\} \quad (\text{A.5}) \end{aligned}$$

$$= \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \bar{C}_p, \quad (\text{A.6})$$

where \bar{C}_p is the average cost per unit over the interval $[0, t_p]$. Note that the expression for \bar{C}_p in (A.6) is a weighted average of (a) units purchased at $(C-D)$ and sold on promotion and (b) forward-bought units purchased at $(C-D)$ and held in inventory before being sold. Similarly, we rearrange Equation (A.4)

$$\begin{aligned} & \left[\frac{\partial Q(P_R)}{\partial P_R} \cdot P_R + Q(P_R) \right] \cdot (\tau - t_p) \\ &= \frac{\partial Q(P_R)}{\partial P_R} \cdot \left[\int_{t_p}^{t_F} I(C-D; t-t_D) dt + \int_{t_F}^{\tau} I(C; 0) dt \right] \\ &\Rightarrow P_R^* = \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \\ &\quad \cdot \left\{ \frac{(t_F - t_p) \int_{t_p}^{t_F} I(C-D; t-t_D) dt}{(t_F - t_p)} + \frac{(\tau - t_F) \int_{t_F}^{\tau} I(C; 0) dt}{(\tau - t_F)} \right\} \quad (\text{A.7}) \end{aligned}$$

$$= \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \bar{C}_R, \quad (\text{A.8})$$

where \bar{C}_R is the average cost per unit over the interval $[t_p, \tau]$. Note that Equations (A.6) and (A.8) correspond to Equations (3.10) and (3.11) given in the text. Finally, Equation (A.2) implies

$$\begin{aligned} & I(C-D; t_p - t_D) \cdot (Q(P_R) - Q(P_p)) \\ &= Q(P_R) \cdot P_R - Q(P_p) \cdot P_p \\ & I(C-D; t_p - t_D) \end{aligned}$$

$$\begin{aligned} &= \frac{Q(P_R) \cdot P_R - Q(P_p) \cdot P_p}{Q(P_R) - Q(P_p)} \\ &\Rightarrow t_p^* = g \left[\frac{Q(P_R) \cdot P_R - Q(P_p) \cdot P_p}{Q(P_R) - Q(P_p)} \mid (C-D) \right] + t_D, \quad (\text{A.9}) \end{aligned}$$

where $\partial I(C; t)/\partial t > 0$, $\forall t > 0$, $\partial I(C; t)/\partial C > 0$ and $g[\cdot \mid C-D] = I^{-1}[\cdot \mid C-D]$. When $(t_p - t_D) = 0$, $I(C-D; t_p - t_D) = C-D$.

Under the assumption that the inventory cost function is given by $I(C; t) = C \cdot \delta^t$ in Equation (3.8), the first-order conditions for Equation (3.9) are

$$\begin{aligned} \frac{\partial \Pi}{\partial t_p} &= Q(P_p) \cdot P_p - Q(P_R) \cdot P_R - Q(P_p) \cdot (C-D) \delta^{t_p - t_D} + Q(P_R) \\ &\quad \cdot (C-D) \delta^{t_p - t_D} = 0 \quad (\text{A.10}) \end{aligned}$$

$$\begin{aligned} \frac{\partial \Pi}{\partial P_p} &= \frac{\partial Q(P_p)}{\partial P_p} \cdot P_p \cdot t_p - \frac{\partial Q(P_p)}{\partial P_p} \\ &\quad \cdot (C-D) \left[t_D + \frac{\delta^{t_p - t_D} - 1}{\ln \delta} \right] = 0 \quad (\text{A.11}) \end{aligned}$$

$$\begin{aligned} \frac{\partial \Pi}{\partial P_R} &= \frac{\partial Q(P_R)}{\partial P_R} \cdot P_R \cdot (\tau - t_p) - \frac{\partial Q(P_R)}{\partial P_R} \\ &\quad \cdot \left[(C-D) + \frac{\delta^{t_F - t_D} - \delta^{t_p - t_D}}{\ln \delta} + C(\tau - t_F) \right] = 0. \quad (\text{A.12}) \end{aligned}$$

Noting that the price elasticity of demand, ϵ_{p^*} is equal to $\partial Q/\partial P \cdot P/Q$, then upon rearranging Equation (A.10) we have

$$\begin{aligned} \delta^{t_p - t_D} &= \frac{P_R^{1+\epsilon_{p^*}} - P_p^{1+\epsilon_{p^*}}}{(C-D)[P_R^{\epsilon_{p^*}} - P_p^{\epsilon_{p^*}}]} \\ \text{so that } t_p^* &= \log_{\delta} \left[\frac{P_R^{1+\epsilon_{p^*}} - P_p^{1+\epsilon_{p^*}}}{(C-D)(P_R^{\epsilon_{p^*}} - P_p^{\epsilon_{p^*}})} \right] + t_D \quad (\text{A.13}) \end{aligned}$$

and similarly for (A.11)

$$\begin{aligned} (\epsilon_{p^*} + 1) \cdot P_p \cdot t_p &= \epsilon_{p^*} \cdot \left[t_D + \frac{\delta^{t_p - t_D} - 1}{\ln \delta} \right] (C-D) \\ \text{so that } P_p^* &= \frac{\epsilon_{p^*}}{\epsilon_{p^*} + 1} \cdot \left\{ \frac{1}{t_p} \cdot \left[t_D + \frac{\delta^{t_p - t_D} - 1}{\ln \delta} \right] \cdot (C-D) \right\} \quad (\text{A.14}) \end{aligned}$$

and finally, for (A.12)

$$\begin{aligned} P_R^* &= \frac{\epsilon_{p^*}}{\epsilon_{p^*} + 1} \\ &\quad \cdot \left\{ \frac{1}{\tau - t_p} \cdot \left[(C-D) \cdot \frac{\delta^{t_F - t_D} - \delta^{t_p - t_D}}{\ln \delta} + C(\tau - t_F) \right] \right\}. \quad (\text{A.15}) \end{aligned}$$

Define the terms in brackets ($\{\}$) as \bar{C}_p and \bar{C}_R , respectively. It is straightforward to see that as in the general case, these terms are obtained by integrating the retailer's unit cost function over the appropriate time horizon

$$\begin{aligned} \bar{C}_p &= \frac{\int_0^{t_D} (C-D) dt + \int_{t_D}^{t_p} (C-D) \cdot \delta^{t-t_D} dt}{t_p} \\ &= \frac{1}{t_p} \cdot \left[t_D + \frac{\delta^{t_p - t_D} - 1}{\ln \delta} \right] \cdot (C-D). \quad (\text{A.16}) \end{aligned}$$

$$\begin{aligned}\bar{C}_R &= \frac{\int_{t_p}^{t_F} (C-D) \cdot \delta^{t-t_p} dt + \int_{t_F}^{\tau} C dt}{(\tau - t_F)} \\ &= \frac{1}{\tau - t_p} \cdot \left[(C-D) \cdot \frac{\delta^{t_F-t_D} - \delta^{t_F-t_p}}{\ln \delta} + C(\tau - t_F) \right]. \quad (\text{A.17})\end{aligned}$$

Thus, given the relationship established in (A.16), we can replace the bracketed term in Equation (A.14) with \bar{C}_p and obtain Equation (3.12) as given in the text. We perform the same operations with Equations (A.17) and (A.15) to yield Equation (3.13), as given in the text.

A.3. Proof of Proposition 1

The cost ordering $I(C-D; 0) < \bar{C}_p < \bar{C}_R < I(C; 0)$ holds because $t_p < t_F$. \bar{C}_p and \bar{C}_R are the average unit costs, and their precise mathematical definitions are given by the terms in brackets ({})) provided in Equations (A.5) and (A.7). We prove Proposition 1 in two parts.

Part 1: Assume that $t_p \geq t_F$. This means that the length of the promotion period extends beyond the initial trade deal period, t_D , and is at least as long as the forward-buy length, t_F . This implies that $I(C; 0) = C$ because the retailer is selling product that has been bought at the regular price but not held in inventory. From Lemma 1 and the solution to Equation (3.6), we know that when $I(C; \cdot) = C$, P_R is the optimal price. If this is true, then the length of the promotion period, t_p , is equal to zero. However, if $t_p = 0$, we cannot have $t_p \geq t_F$. This is a contradiction. Hence, we have $t_p < t_F$.

Part 2: $t_p < t_F$. Given that $t_p < t_F$, then $I(C-D; 0) < \bar{C}_p < \bar{C}_R < I(C; 0)$ because in the range $[0, \tau]$ the function $I(C; t)$ is monotonically increasing in t . In the range $[0, t_D]$, we have $I(C; t) = C-D$, and in $[t_F, \tau]$ we have $I(C; t) = C$. Between t_D and t_F , unit costs are monotonically increasing in t and by the Mean Value Theorem $\bar{C}_p < \bar{C}_R$ (see Figure 1). \square

A.4. Proof of Proposition 2

Lemma 1 states that $P^* = \epsilon_{p^*}/1 + \epsilon_{p^*} \cdot \bar{C}$, where ϵ_{p^*} is the price elasticity of demand. The following observations hold (even without specifying a functional form for demand):

1. The retailer will always price in the elastic portion of the demand curve (in the inelastic part profits can always be increased by raising prices), so that $\epsilon_{p^*}/1 + \epsilon_{p^*}$ will always be greater than 1, and prices exceed costs.
2. If $C_i = C_j$, then $P_i = P_j$, $Q_i = Q_j$, and thus $\Pi_i = (P_i - C_i) \cdot Q_i = \Pi_j$. Therefore, a retailer facing the same costs under two different scenarios, i and j , will make the same amount of profits under each scenario and will thus be indifferent between the two.

Point 2 is essential to the proof. We now show how average unit costs during promotion and nonpromotion periods change under scan-back and off-invoice deals.

Retailer Costs and Profits Under Off-Invoice. A retailer facing a deal size D , regular cost C , and deal length t_D acts as follows:

- The trade deal induces a forward-buy of n periods [Equations (3.7) and (3.8)]. The length of the forward-buy period is $t_F = t_D + n$.
- Given t_F , the promotion will exceed t_D and stop sometime before t_F . This is because at t_D , the cost of goods sold is $I(C-D; 0) =$

$C-D$ and promotion is warranted. At t_F , the cost of goods sold is $I(C; 0) = C$, at which point the regular price is optimal. Therefore t_p (the optimal promotion length) lies between t_D and t_F (see Appendix A.3).

- Given t_p , the average cost of goods sold during the promotion is $\bar{C}_p(t_p)$, and the average cost of goods sold during nonpromotion is $\bar{C}_R(t_p)$. The optimal prices are given in Equations (3.10) and (3.11).
- The overall retail profit for the time horizon $[0, \tau]$ is the sum of the profits during the promotion period, $\Pi(P)$, and the nonpromotion period, $\Pi(R)$

$$\begin{aligned}\Pi(P) &= t_p \cdot Q(P_p) \cdot \left\{ \left(\frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \right) \cdot \bar{C}_p(t_p) - \bar{C}_p(t_p) \right\} \\ &= t_p \cdot Q(P_p) \cdot \bar{C}_p(t_p) \cdot \left\{ \left(\frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \right) - 1 \right\} \quad \text{and} \\ \Pi(R) &= (\tau - t_p) \cdot Q(P_R) \cdot \bar{C}_R(t_p) \left\{ \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} - 1 \right\}.\end{aligned}$$

Manufacturer Redesigns Scan-Back to Mimic Off-Invoice. Consider what happens if instead of an off-invoice trade deal of D for t_D periods, with a regular price of C , the retailer is faced with a scan-back trade deal of $(\bar{C}_R^* - \bar{C}_p^*) = D'$ for t_p^* periods, with a regular price of \bar{C}_R^* .

- In the absence of forward-buying, i.e., the scan-back case, $t_p^* = t_D^*$. This means the optimal lengths for the promotion period (t_p^*) and the nonpromotion period (t_p to τ), are now identical to the base off-invoice case.
- During the nonpromotion period (t_p, τ), the retailer faces cost of good solds of \bar{C}_R^* and sets the regular price at $P_R = \frac{\epsilon_{p^*}}{1 + \epsilon_{p^*}} \cdot \bar{C}_R^*$, which is the same price as that in the off-invoice case. This generates the same amount of profit, $\Pi(R)$.
- During the promotion period, the unit cost of goods sold of $\bar{C}_R^* - (\bar{C}_R^* - \bar{C}_p^*) = \bar{C}_p^*$, which is the same as the off-invoice case. Again, for this period of time, promotion-period profits are the same as in the off-invoice case.
- Given identical promotion length, average cost of goods sold in the promotion period, average cost of goods sold in the regular price period, promoted price, regular price, promoted profits, and regular profits, the retailer is indifferent between the two situations.

This redesigned scan-back trade deal produces retail profits that are identical to those generated under off-invoice.

Manufacturers Are Strictly Better Off with Redesigned Scan-Back. To show that manufacturers prefer the scan-back, we examine how retailer profits are generated. We have just shown that, for the retailer $\Pi(RSB) = \Pi(OI) = t_p \cdot Q(P_p) \cdot (P_p - \bar{C}_p) + (\tau - t_p) \cdot Q(P_R) \cdot (P_R - \bar{C}_R)$, where RSB and OI refer to “redesigned scan-back” and off-invoice, respectively. Note that we have separated the profits into two pieces: those that accrue during the promotion period (from time 0 to t_p) and those that arise in the nonpromotion period (from t_p to τ).

To see how the manufacturer fares under the two schemes, we make use of the fact that cost of goods sold (COGS) for the retailer

are equivalent to revenues for the manufacturer. We start by rewriting the retailer profits in a way that separates revenues and costs

$$\begin{aligned}\Pi(RSB) &= \Pi(OI) \\ &= [t_p \cdot Q(P_p) \cdot P_p + (\tau - t_p) \cdot Q(P_R) \cdot P_r] \\ &\quad - \left[t_p \cdot Q(P_p) \cdot \bar{C}_p + (\tau - t_p) \cdot Q(P_R) \cdot \bar{C}_R \right].\end{aligned}$$

Profits are identical under each condition, as are the prices charged and quantities sold. As a result, the *total* costs incurred by the retailers also have to be equal in each condition [i.e., $TC(RSB) = TC(OI)$]. These costs incurred by the retailer are simply the sum of the monies paid to the manufacturer, COGS, and the incurred inventory costs, IC . This implies

$$\begin{aligned}C(RSB) &= COGS(RSB) + IC(RSB) \\ C(OI) &= COGS(OI) + IC(OI).\end{aligned}$$

Under the scan-back, the retailer does not incur inventory costs, so that $IC(SB) = 0$. Under the off-invoice trade deal, the retailer incurs inventory costs on the forward-bought items, $IC(OI) > 0$. Because $TC(RSB) = TC(OI)$, it follows that $COGS(RSB) = COGS(OI) + IC(OI)$, or $COGS(RSB) > COGS(OI)$.

If we assume that the manufacturer is efficient and produces what he sells without carrying inventory, profits will be equal to the difference between revenues and costs of production. As the number of units produced under each scenario (off-invoice and scan-back) is the same, manufacturer costs will be identical. Manufacturer revenue, on the other hand, will equal the COGS of the retailer—that is, either $COGS(RSB)$ or $COGS(OI)$. We have just shown that $COGS(RSB) > COGS(OI)$, so the manufacturer receives greater revenues under scan-back than under off-invoice, while facing the same costs of production. This implies that manufacturer profits must be higher.

A.5. Optimal Values for the Illustration

The first-order conditions of the retailer's problem given in Equation (3.9), when $Q(P) = \alpha_0 P^{\alpha_1}$ and $t_D = 1$, are

$$\begin{aligned}\frac{\partial \Pi}{\partial t_p} &= \alpha_0 P_p^{\alpha_1+1} - \alpha_0 P_R^{\alpha_1+1} - \alpha_0 P_p^{\alpha_1} (C-D) \delta^{t_p-1} \\ &\quad + \alpha_0 P_R^{\alpha_1} (C-D) \delta^{t_p-1} = 0\end{aligned}\quad (A.18)$$

$$\begin{aligned}\frac{\partial \Pi}{\partial P_p} &= \alpha_0 (\alpha_1 + 1) P_p^{\alpha_1} t_p - \alpha_0 \alpha_1 P_p^{\alpha_1-1} (C-D) \\ &\quad \cdot \left[1 + \frac{\delta^{t_p-1} - 1}{\ln \delta} \right] = 0\end{aligned}\quad (A.19)$$

$$\begin{aligned}\frac{\partial \Pi}{\partial P_R} &= \alpha_0 (\alpha_1 + 1) P_R^{\alpha_1} (\tau - t_p) - \alpha_0 \alpha_1 P_R^{\alpha_1-1} \\ &\quad \cdot \left[(C-D) + \frac{\delta^{t_F-1} - \delta^{t_p-1}}{\ln \delta} + C(\tau - t_F) \right] = 0.\end{aligned}\quad (A.20)$$

Rearranging Equation (A.18), we have

$$\begin{aligned}\delta^{t_p-1} &= \frac{P_R^{\alpha_1+1} - P_p^{\alpha_1+1}}{(C-D)[P_R^{\alpha_1} - P_p^{\alpha_1}]} \\ \text{so that } t_p^* &= \log_{\delta} \left[\frac{P_R^{\alpha_1+1} - P_p^{\alpha_1+1}}{(C-D)(P_R^{\alpha_1} - P_p^{\alpha_1})} \right] + 1\end{aligned}\quad (A.21)$$

and similarly for (A.19)

$$\begin{aligned}(\alpha_1 + 1) P_p t_p &= \alpha_0 \left[1 + \frac{\delta^{t_p-1} - \delta}{\ln \delta} \right] (C-D) \\ \text{so that } P_p^* &= \frac{\alpha_1}{\alpha_1 + 1} \cdot \frac{1}{t_p} \cdot \left[1 + \frac{\delta^{t_p-1} - 1}{\ln \delta} \right] \cdot (C-D)\end{aligned}\quad (A.22)$$

and finally, for (A.20)

$$P_R^* = \frac{\alpha_1}{\alpha_1 + 1} \cdot \frac{1}{\tau - t_p} \cdot \left[(C-D) \cdot \frac{\delta^{t_F-1} - \delta^{t_p-1}}{\ln \delta} + C(\tau - t_F) \right].\quad (A.23)$$

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