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# Managing retail channel overstock: Markdown money and return policies

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**Abstract**

This paper studies a manufacturer-retailer channel facing unknown demand. When the wholesale relationship comprises only a per-unit price that exceeds the manufacturing cost, the retailer's inventory strategy will not properly reflect the channel's overstock and understock costs. A number of researchers have advocated manufacturer return policies to remedy this misalignment of incentives, but none explain the reality that "markdown money" is sometimes paid to retailers expressly to avoid product returns. We formulate a model that distinguishes between these practices, and determine conditions under which each will be more desirable with respect to channel coordination and individual firm performance. 

*Keywords:* channel coordination; channels of distribution; markdown allowance; markdown money; return policies; pricing; inventory management; supply chain management

## 1. Introduction

On July 1, 1997, Procter & Gamble implemented "Streamlined '97", a set of channel policies directly aimed at reducing returns from the retailers that distribute P&G products to the consumer mass market. In one significant component of this initiative, P&G began offering *markdown money*[1] in place of return privileges for discontinued items through its "Discontinued Products Transitions Program" (Tenser 1997). According to Marc Pritchard of P&G Cosmetics, "Once we're clear of the old program, we expect the new program to

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work even better as it provides our retailers with the opportunity to sell through discontinued products and to save handling costs instead of returning these products (Klepacki 1998)." To understand these developments, we must consider the purposes of the two approaches, and any differences between them.

If a product has a finite selling season and uncertain demand, retail overstock is a possibility. Anticipating how such surplus will devalue, the retailer may stock less of the item than the manufacturer would like, if any at all. As illustrated by P&G, manufacturer return policies and markdown money are two common strategies used by manufacturers to combat this tendency. Both work by decreasing the retailer's net cost of overstock.

Return policies are often observed when demand is unpredictable and/or the risk of obsolescence is high, as extensively documented by Padmanabhan and Png (1995) and Kandel (1996). Markdown money also has a rich tradition among products facing such environments, including fashion apparel (Ryan 1998; Monget 1998), cosmetics and fragrances (Parks 1996), toys (Leccese 1993), specialty products (Gallagher 1999), certain food categories and over-the-counter medications (Tenser 1997). However, nothing in our discussion thus far suggests if, when, or why either method might be preferable to the other.

The academic literature is silent on these questions. Return policies are certainly relatively well-studied (Pasternack 1985; Kandel 1996; Padmanabhan and Png 1997; Emmons and Gilbert 1998; Donohue 2000; Webster and Weng 2000), as will be discussed in greater detail in the next section. These works advocate return policies as a way to improve the efficiency of the channel to the participants' mutual benefit. However, this conclusion relies on two assumptions that mask the differences between the practices in question:

(1) the physical return of product does not incur additional cost, and
(2) the channel members are equally effective at liquidating overstock[2].

The first assumption is problematic in that the handling, logistics, and administrative overhead associated with moving product back up the channel may be substantial. For instance, P&G Cosmetics has calculated that each handling of an item (because of damage, discontinuation, or simple return) costs 34 cents, a nontrivial fraction of typical profit margins for such products (Born 1997). And Hal Upbin, CEO of Kellwood Co. (a manufacturer of ready-to-wear apparel) notes, "We don't take anything back; the cost of handling would be absurd (Infotracs 1997)."

With respect to the second assumption, the reality is that recovering value from surplus product is a substantive professional competency, and different parties likely have different aptitude and tolerance for this (Hungerford 1999). The retailer obviously has the most immediate option, i.e., to sell to the same customer base at a discount. Indeed, access to markets and comparative advantage in merchandising are among the underlying reasons a retail channel would be used in the first place, and these factors should persist at the clearance phase. However, if the residual value comes from recovering and reusing the raw materials, the manufacturer could have an advantage. Also, by consolidating the returns from multiple retailers a manufacturer might be able to assemble an assortment that becomes economically viable for resale to a discount specialist (e.g., T. J. Maxx in the apparel industry). Additional aging of the product and potential damage during the processing of returns should be considered, of course. Similar points are raised, but not formally pursued, by Kandel (1996) and Padmanabhan and Png (1997).

The objective of this article is to differentiate the channel policies associated with product overstock by relaxing the two assumptions highlighted above. To do this, we will present ideas about the management of overstock, introduce and assess existing research by discussing various modeling approaches, and provide some new theoretical and numerical results that illuminate the practice of markdown money and how it reflects the balance of strategic balance in the channel. The analysis will include a demonstration that the consequences of ignoring handling costs and salvage value asymmetries can be substantial.

## 2. Literature overview and modeling preliminaries

This section will provide a proper context by introducing common approaches to modeling the settings in which return policies and markdown money have been observed. We will focus on frameworks with substantial precedent in studying distribution channels facing uncertain demand.

As noted earlier, the general setting is one in which inventory commitments must be made before uncertainty about market demand is fully resolved. In a variety of business disciplines this has often motivated the application of some variant of the "newsvendor" model, whose assumptions will be reviewed below. This model has long been a cornerstone of the literature of inventory theory (cf. Porteus 1990; Lee and Nahmias 1993), but some incarnation has been employed by accountants (e.g., Shih 1979; Narayanan and Raman 1997), decision scientists (e.g., Ismail and Louderback 1979; Lau 1980a; Lau 1980b), economists (e.g., Edgeworth 1888; Arrow *et al.* 1951; Mills 1959; Mills 1962; Kandel 1996), marketers (e.g., Riter 1967; Pasternack 1985), and undoubtedly others. This has come to be considered the most appropriate basic conceptual framework for understanding the management of "style goods," defined as products with significantly uncertain demand and a selling season much shorter than the time frame for production/replenishment (e.g., Wadsworth 1959; Hertz and Schaffir 1960; Murray and Silver 1966; Ravindran 1972; Hausman and Peterson 1972; Crowston *et al.* 1973; Hartung 1973; and more recently Fisher and Raman 1996; Eppen and Iyer 1997; Weng 1997; Emmons and Gilbert 1998; Donohue 2000). Examples of these include fashion apparel, skiwear, toys, dress shoes, and many consumer electronics categories. For this reason the model is frequently used by MBA instructors to illustrate such settings (Rudi and Pyke 2000), and has been featured in a recent *Harvard Business Review* article (Fisher *et al.* 1994).

Among the key strengths of the model are (i) it explicitly represents demand uncertainty, which is obviously a central motive for both return policies and markdown money, and (ii) its recommendations comprehend the economics of overstocking and understocking in an intuitively consistent fashion. While often applicable in practice, this model is particularly popular among academic researchers seeking to frame an inventory problem in as simple of mathematical terms as possible to obtain structural insights. This article shares such a motivation.

### 2.1. The newsvendor model structure

The newsvendor model derives its name from a problem faced by a retailer of newspapers, who faces a random demand and must choose at the beginning of the day how many papers to stock. Due to the lead times for printing and distribution, there is no opportunity to reorder papers during the day. Since unsold papers have little value at the day's end, the retailer has a motive not to stock too many. On the other hand, having stock on hand is necessary to satisfy customers and earn profit. The profit-maximizing strategy strikes a balance between the penalty for overstocking and the penalty for understocking, taking into consideration the relative likelihood of each circumstance. To be mathematically precise, define the following variables:

$p$ = retail price per unit
$w$ = wholesale price per unit
$s_R$ = retailer's salvage value per unit
$g_R$ = goodwill loss per unit of retail stockout
$Q$ = amount ordered by the retailer
$X$ = stochastic demand, with expected value $\mu$, probability density $f(x)$, and cumulative distribution $F(x)$, which is assumed to be differentiable and invertible

The variable $s_R$ plays a key role in describing any residual value for overstocked product. A high value means that the penalty for overordering is small, as would be the case for stable products an apparel retailer might call "basics". A low value reflects a significant rate of obsolescence, a defining attribute of "fashion" items. This salvage value could be realized in a number of ways, including liquidation at a clearance price, recycling, or tax credit for donating the product to charity. The model assumes $p > w > s_R$ for obvious reasons.

The retailer's expected profit, which we denote as $\pi_R$, can be written as

$$\pi_R \equiv -Qw + \int_0^Q [px + (Q - x)s_R] f(x)dx + \int_Q^\infty [pQ - (x - Q)g_R] f(x)dx \qquad (1)$$

The first expression on the right side of equation (1) is, of course, the total procurement cost. The second expression accounts for all overstock scenarios ($X \leq Q$). With $x$ denoting the specific realization of $X$, $px$ is the sales revenue and $(Q - x)s_R$ is the total value recoverable from the surplus. The third expression corresponds to stockout scenarios ($X > Q$). Here, all available stock will sell out for $pQ$ in total revenue, triggering a total goodwill loss of $(x - Q)g_R$.

In the basic model the order quantity is the retailer's only decision. The profit-maximizing choice, which we denote as $Q^*$, can be obtained in a straightforward fashion by solving the first-order condition $d\pi_R/dQ = 0$, and confirming the second derivative $d^2\pi_R/dQ^2$ to be strictly negative. The explicit solution is

$$Q^* = F^{-1}\left(\frac{p + g_R - w}{p + g_R - s_R}\right) \qquad (2)$$

Of course, many real retail settings deviate from this simple model in any number of ways. For instance, the model collapses the entire time line for planning and selling into the following sequence of discrete events: (i) all supply is ordered and delivered, (ii) all demand occurs, and (iii) any surplus is liquidated. While in the newspaper retailer's story this was appropriate because all events transpire within a single day, in most settings each phase could take several weeks or more, and there might be overlap between activities. The simplification thus reduces the dimensionality of every environmental factor and decision, each of which could otherwise vary virtually continuously over time. Recent examples that attempt to represent this type of complexity are Agrawal *et al.* (2000) and Smith *et al.* (2000), which created decision support software for the private-label products of a major apparel retailer. Such formulations tend to require specialized optimization algorithms and extensive parameter estimation, and the majority of the conclusions tend to depend specifically on the parameters used. The newsvendor simplification of reality is usually invoked when the product life cycle is short and the selling season allows little time for reordering, as is usually the case for style goods.

There are also implications of the structure imposed on each of the economic factors. For instance, removing the exogenous specification of the retail price[3] would allow a retailer to jointly choose $p$ and $Q$ to best respond to the market's price-sensitivity. Petruzzi and Dada (1999) provide a recent review of such models. Generally, the optimal *quantity* at a given retail price satisfies the condition given in equation (2). However, even in the single-firm setting the optimal *price* may be derived in closed form only under very specific assumptions about the structure of market demand. As a result, the majority of newsvendor applications assume $p$ to be exogenous. In this article we will consider both exogenous and endogenous retail price.

The end-season activities to recover value from overstock are collectively approximated by a constant per-unit salvage value that is beyond the retailer's control. As noted, the newsvendor model collapses revenue-generating activity that may last multiple weeks or longer into two discrete "selling" events. An uncertain amount is initially demanded at price $p$, and then an unlimited demand occurs at the lower price $s_R$.

The particulars sacrificed in this simplification may be appreciated by comparison to a recent study by Smith and Achabal (1998), which closely examines clearance practices in retail chains. Specifically, they studied how to design a retailer's pricing plan (scheduled promotions as well as the discount trajectory used to close out a product's life) over the course of a finite, multiperiod selling season to extract maximum profit from a one-shot initial inventory purchase. So rich a treatment of pricing strategy was enabled by assuming away demand uncertainty. In the basic newsvendor formulation this would eliminate salvage altogether since supply could always be perfectly matched to demand. But in Smith and Achabal's work, the inventory level is assumed to influence the rate of sales. For instance, customers react to a product's in-store presentation, a dimension of which is the amount of inventory displayed. This may create an incentive to overstock at certain epochs, in spite of the resulting excess at the season's close (which is then liquidated at an exogenous, per-unit price as in the newsvendor model).

The newsvendor model's simplifying structure can be rationalized in a number of ways. One argument is that at the stage of negotiating contracts with vendors, which is often significantly far in advance of the selling season, the eventual clearance strategy is very difficult to anticipate. A reasonable approximation, and one that is used in practice, will then be to estimate an expected per-unit salvage value. A similar logic could be applied to the use of a single retail price to capture any dynamic price maneuvering that may ultimately transpire during the season.

Other simplifying assumptions are embedded in the newsvendor formulation. However, its regular recurrence in new theoretical and applied research serves as testimony to its strengths.

### *2.2. Modeling distribution channel policies*

By expanding the scope to include the manufacturer of the product sold through the retail channel, the newsvendor framework has been used by numerous researchers to examine a variety of channel policies (cf. Tsay *et al.* 1999). Typically the manufacturer is assumed to produce exactly the quantity ordered, incurring a per-unit production cost of $c$ and in turn collecting from the retailer the per-unit wholesale price of $w$. The manufacturer also suffers a goodwill loss of $g_M$ per unit when the retailer stocks out, since this may diminish end customers' loyalty to the brand.

As an illustration, consider the most commonly studied manufacturer return policy, in which the retailer may return up to a fraction $R$ of the original order for a per-unit rebate of $b$. The returned products have a value to the manufacturer of $s_M$ per unit. Under these assumptions, the manufacturer's expected profit, which we denote as $\pi_{M,return}$, can be written as

$$\pi_{M,return} \equiv Q(w-c) - \int_0^{(1-R)Q} RQ(b-s_M)\, f(x)dx$$

$$- \int_{(1-R)Q}^{Q} (Q-x)(b-s_M)\, f(x)dx - \int_Q^{\infty} (x-Q)\, g_M\, f(x)dx \tag{3}$$

The first expression on the right hand side of (3) is the retailer's original wholesale payment less the cost of production. The second expression evaluates the expected net cost to the manufacturer due to returns when market demand is so low that the retailer will return the maximum allowable amount. The third expression addresses the case in which the retailer returns an amount less than the maximum allowable. The fourth expression is the manufacturer's expected goodwill loss due to retail stockouts.

The retailer's expected profit, denoted as $\pi_{R,return}$, can similarly be written as

$$\pi_{R,return} \equiv -Qw + \int_0^{(1-R)Q} [px + RQb + ((1-R)Q - x)s_R]\, f(x)dx$$

$$+ \int_{(1-R)Q}^{Q} [px + (Q-x)b]\, f(x)dx + \int_Q^{\infty} [pQ - (x-Q)\, g_R]\, f(x)dx \tag{4}$$

where the second and third terms in the right side of equation (4) are what becomes of the second expression on the right hand side of (1) under the stated return policy. Note that when $R = 0$ (which disallows returns) or $b = s_R$ (so that the retailer is indifferent between returns and salvaging the overstock), (4) reverts back to (1) as would be expected.

Given the stated structure, a return policy is uniquely defined by a set of values for ($R$, $w$, $b$). This in turn fixes each party's expected profit according to equations (3) and (4), independently of which party sets which of the variables, and in what sequence. Researchers then typically seek to ascertain which unique policy will result when both parties act in their individual best interests, and the associated channel inventory pattern and profit allocation. This can be established using concepts from game theory once a decision structure is assumed.

The decision structure represents relative strategic power in the channel. Nearly every analysis of returns or similar policies across a variety of literatures assumes the manufacturer to be the channel captain. This would be reasonable when a large manufacturer with a powerful brand deals with a small to mid-sized retail firm. Such a manufacturer takes Stackelberg leadership in a game with the following decision sequence: (i) the manufacturer dictates ($R$, $w$, $b$), (ii) the retailer decides whether to carry the product and then how large a $Q$ to order (as well as what retail price to set, if $p$ is a decision variable). However, a powerhouse retailer such as Walmart might dictate all the terms along with choosing $Q$ (and possibly $p$). None of the works mentioned have addressed this possibility. We will consider both cases in our discussion.

For a given a decision structure, the equilibrium may be derived by the game-theoretic technique of reverse induction. For instance, when the manufacturer is the channel captain, the first calculation would be the retailer's choice of $Q$ to maximize $\pi_{R,return}$ for a given ($R$, $w$, $b$), via the same method that produced (2). The next calculation would be the manufacturer's selection of ($R$, $w$, $b$) to maximize $\pi_{M,return}$, anticipating how the retailer would order.

This approach underlies virtually all existing model-based research on return policies. The seminal work appears to be by Pasternack (1985), who found that for a single-period setting with the manufacturer as channel captain, a properly designed policy allowing full returns ($R = 1$) at partial credit ($b < w$) can coordinate the channel to the benefit of both parties. Donohue (2000) obtains similar results for a two-period model. Kandel (1996) and Emmons and Gilbert (1998) discuss the single-period case in which retail price is also a decision. Both argue that full coordination is no longer possible unless the manufacturer can control this price (e.g., through "Resale Price Maintenance"), but the latter researchers guarantee the existence of a Pareto-improving, full-return policy for a specific form of demand (demand per customer is deterministic and linearly decreasing in the retail price, and the number of customers is a uniform random variable). Webster and Weng (2000) provide conditions under which a manufacturer can assure itself no less profit than it would obtain absent a return policy, while leaving the retailer no worse off on average, thus overcoming potential risk-sensitivity in the manufacturer's preferences.

It is worth mentioning Padmanabhan and Png (1997), the one published study in this literature that does not use newsvendor structure to model the retailer. This considers a single retailer facing a very simple form of stochastic demand, or two retailers competing for a deterministic market described by a linear demand curve. The manufacturer takes leadership in choosing one of two extreme policies and the associated wholesale price: no returns, or full returns at full price. Demand is unknown when the retail inventory is ordered. However, the retail price is not set until demand is revealed, and is determined by an assumption that the price must be lowered to whatever point is necessary to completely sell all available stock. All units are sold at this single price. While this modeling abstraction captures a retailer's economic motive for not ordering excessively, it avoids the counting of overstock altogether. Consequently, this approach cannot explicitly represent the channel practices we wish to investigate.

In this study we will begin with modeling precedent set by Pasternack (1985) and those that followed, in terms of the newsvendor-based channel model outlined above. In particular, we will retain their assumptions of exogenous and constant unit salvage values. This will allow a focus on the reality in which different parties have different liquidation prospects without undermining our ability to compare our findings with existing literature. An approach such as Smith and Achabal's is not used due to our setting's number of parameters and the multi-firm scope, as well as our interest in a different set of questions. Our analysis will consider cases in which each party is the channel captain. While a number of insights will be obtained under the assumption of exogenous retail price, we will also consider retail price-setting. The next section briefly reviews the essential parts of Pasternack's formulation and conclusions to provide a point of departure for our more general analysis.

## 3. Return policies

Pasternack (1985) considered a single-selling-period, single-product setting with uncertain demand. The manufacturer dictates the unit wholesale price for the retailer's one-time purchase prior to a selling season, the percentage of the purchase allowed to be returned after the season, and the rebate per unit returned. In turn, the retailer chooses an order quantity. Pasternack's main findings are:

- Allowing the retailer *unlimited returns for full credit* (sometimes termed "consignment") is system suboptimal.
- Allowing the retailer *no returns* is system suboptimal[4].
- Allowing the retailer *unlimited returns at partial credit* will be system optimal for appropriately chosen combinations of the wholesale price and return rebate.
- There is a continuum of channel-coordinating, unlimited-return policies that is *independent of the distribution of market demand*, so that the manufacturer need not possess the retailer's demand information to design a coordinating policy.
- The resulting coordinated system profit *can be allocated arbitrarily* by proper choice of the wholesale price and return rebate. This assures that each party will willingly participate in such a relationship relative to any (inefficient) alternative.

To refine these results, consider the following variables, commonly known by both parties:

$p$ = retail price per unit
$w$ = wholesale price per unit, paid by the retailer to the manufacturer
$c$ = manufacturing cost per unit
$s_i$ = salvage value per unit when liquidated by party $i$, where $i = M$ refers to the manufacturer and $i = R$ refers to the retailer
$g_i$ = party $i$'s goodwill loss per unit of retail stockout; $i \in \{M, R\}$
$g \equiv g_R + g_M$ = total goodwill loss per unit of retail stockout
$b$ = credit per unit returned, paid by the manufacturer to the retailer
$t_i$ = handling/shipping cost incurred by party $i$ per unit returned; $i \in \{M, R\}$
$Q$ = amount ordered by the retailer at a price of $w$ per unit
$R$ = fraction of $Q$ the retailer is entitled to return to the manufacturer for a credit of $b$ per unit
$X$ = stochastic demand, with expected value $\mu$, probability density $f(x)$, and cumulative distribution $F(x)$, which is assumed to be differentiable and invertible
$V_i$ = party $i$'s reservation value, defined as the highest expected profit that could be obtained from an alternative to the channel relationship under consideration; $i \in \{M, R\}$

The $s_i$ variables allow the two parties distinct prospects for salvage, and are net of any costs incurred in the course of liquidating the surplus (e.g., for re-tagging products). The $t_i$ variables indicate that nontrivial costs may accrue to either or both parties on executing a return, e.g., for removing the product from the selling floor, invoicing, packaging, transportation, etc. A physical flow back to the manufacturer is not necessary for these costs to arise. For instance, manufacturers occasionally buy back ownership of surplus from retailers, but arrange for direct shipping to third-party clearance specialists (cf. Ono 1998). This may reduce the handling/logistics expenses, but does not avoid them.

Three relationships are used to constrain the parameters: (i) $s_R, s_M < c < w + g_M$, (ii) $s_R < b - t_R \leq w < p + g_R$, (iii) $b + t_M > s_M - g_M$. In (i), the first inequality is to discourage producing directly to salvage, and the second is necessary for the manufacturer's participation. In (ii), the first inequality is required because otherwise the retailer would ignore any return policy and dispose of the surplus on its own, the second is to discourage buying product expressly to return it, and the third is necessary for the retailer's participation. The effect of (iii) is to prevent the manufacturer from trying to buy more back from the retailer than necessary. Together these are sufficient for consistency of the system-optimization scenario as well. All decision makers seek to maximize individual expected profit.

### 3.1. System performance benchmark

The expected profit for the entire system, which we denote as $\pi_T$, is:

$$\pi_T \equiv -Qc + \int_0^{(1-R)Q} [px + RQ(s_M - t_R - t_M) + ((1 - R)Q - x)s_R] f(x)dx$$

$$+\int_{(1-R)Q}^{Q}[px+(Q-x)(s_M-t_R-t_M)]f(x)dx+\int_{Q}^{\infty}[pQ-(x-Q)g]f(x)dx \tag{5}$$

This expression can be obtained by adding equations (3) and (4), and incorporating the handling costs in the appropriate places. The goal of the channel is to choose the $Q$ and $R$ that maximize $\pi_T$. The optimal policy, denoted as $Q^*$ and $R^*$, is described in Proposition 1. We will subsequently refer to the corresponding optimal value of the expected system profit as $\pi_T^*$.

**PROPOSITION 1.** *The decisions that maximize expected system profit are as follows: (i) If the net value recoverable through retail liquidation of overstock is higher than that attainable through manufacturer liquidation* (*i.e.,* $s_R > s_M - t_R - t_M$), *the optimal initial stocking level is* $Q^* = F^{-1}((p + g - c)/(p + g - s_R))$ *and any overstock should be liquidated by the retailer* (*i.e.,* $R^* = 0$).

*(ii) Otherwise, the optimal initial stocking level is* $Q^* = F^{-1}((p + g - c)/(p + g - (s_M - t_R - t_M)))$ *and any overstock should be liquidated by the manufacturer* (*i.e.,* $R^* = 1$). ■

This decoupling of $R$ and $Q$, and the importance of the relative magnitudes of $s_R$ and $(s_M - t_R - t_M)$ are entirely intuitive. The optimal strategy liquidates overstock exclusively by whichever option provides the highest net salvage value (adjusted for handling costs).

### *3.2. Performance with independent manufacturer and retailer*

Next consider a return contract with parameters ($R$, $w$, $b$). Once these are fixed, the retailer chooses the order quantity that will maximize the expected retail profit $\pi_{R,return}$, which is equation (4) modified for handling costs as seen below:

$$\pi_{R,return} \equiv -Qw + \int_{0}^{(1-R)Q}[px + RQ(b-t_R) + ((1-R)Q-x)s_R]f(x)dx$$

$$+\int_{(1-R)Q}^{Q}[px+(Q-x)(b-t_R)]f(x)dx+\int_{Q}^{\infty}[pQ-(x-Q)g_R]f(x)dx \tag{6}$$

The retailer's optimal order will be determined by the first-order condition

$$\frac{d\pi_{R,return}}{dQ} = p + g_R - w - (p + g_R - b + t_R)F(Q) - (1-R)(b - s_R - t_R) \times F((1-R)Q) = 0 \tag{7}$$

and we define $\hat{Q}_{return}$ to be the unique solution to equation (7). Second-order conditions verify this to be a global maximum.

The manufacturer's expected profit is equation (3) adjusted for handling costs as follows:

$$\pi_{M,return} \equiv Q(w - c) - \int_0^{(1-R)Q} RQ(b + t_M - s_M) f(x)dx - \int_{(1-R)Q}^{Q} (Q - x)(b + t_M - s_M) f(x)dx - \int_Q^{\infty} (x - Q) g_M f(x)dx \tag{8}$$

Which calculation to perform next depends on which party enjoys the status of channel captain. This party will choose $(R, w, b)$ to maximize its own expected profit given that the induced order quantity will be $\hat{Q}_{return}$. This will determine both parties' expected profits. How these values compare to the exogenously determined reservation values $V_R$ and $V_M$ will dictate whether the two parties will agree to do business at all. $\pi_{R,return} \geq V_R$ is required for the retailer to participate, and likewise $\pi_{M,return} \geq V_M$ must also hold. The sum $V_R + V_M$ must not exceed $\pi_T^*$, or no supply relationship will be sustainable.

Proposition 2 reevaluates Pasternack's conclusions in light of our modifications.

**PROPOSITION 2.** *A manufacturer return policy has the following implications: (i) If the net value recoverable through manufacturer liquidation of overstock is greater than that recoverable through retailer liquidation (i.e., $s_R \leq s_M - t_R - t_M$):*

*(a) The channel can be coordinated with any of a continuum of full-return policies with the form $(R, w, b) = (1, \bar{w}(b), b)$, where*

$$\bar{w}(b) \equiv p + g_R - \frac{(p + g - c)(p + g_R - (b - t_R))}{p + g - (s_M - t_R - t_M)} \tag{9}$$

*(b) When the retailer incurs handling costs for processing returns (i.e., $t_R > 0$), there exists a continuum of channel-coordinating, full-return policies in which the manufacturer provides not only full credit for returns, but may even subsidize the retailer's handling costs. These are characterized by*

$$b \in \left[ p + g_R - t_R\left(\frac{p + g - c}{c - (s_M - t_R - t_M)}\right), p + g_R + t_R\right).$$

*(c) For a given channel-coordinating return rebate, which will be uniquely determined by the value of b, the expected profits for the two parties are*

$$\bar{\pi}_{R,return} \equiv (p - b + t_R)\int_0^{Q^*} xf(x)dx - g_R\int_{Q^*}^{\infty} xf(x)dx$$

$$\bar{\pi}_{M,return} \equiv (b + t_M - s_M)\int_0^{Q^*} xf(x)dx - g_M\int_{Q^*}^{\infty} xf(x)dx$$

*so that increasing b within the allowable range of $(s_M - t_M - g_M, p + g_R + t_R)$ benefits the manufacturer at the retailer's expense.*

*(d) When the manufacturer is the channel captain (Stackelberg leader with regard to the channel policy), the equilibrium will be the full return policy uniquely specified by*

$$b = p + t_R - \frac{V_R + g_R \int_{Q^*}^{\infty} x f(x) dx}{\int_0^{Q^*} x f(x) dx}$$

*with corresponding expected profits of*

$$\pi_{R,return} = V_R \pi_{M,return} = \pi_T^* - V_R \geq V_M$$

*(e) When the retailer is the channel captain, the equilibrium will be the full return policy uniquely specified by*

$$b = s_M - t_M + \frac{V_M + g_M \int_{Q^*}^{\infty} x f(x) dx}{\int_0^{Q^*} x f(x) dx}$$

*with corresponding expected profits of*

$$\pi_{R,return} = \pi_T^* - V_M \geq V_R$$

$$\pi_{M,return} = V_M$$

*(ii) If the retailer has the liquidation advantage* (*i.e.*, $s_R > s_M - t_R - \mathrm{t_M}$), *no return policy can coordinate the channel. This is true regardless of which party is the channel captain.* ■

This proposition reveals that there are now two conditions for system efficiency: having the right inventory on hand *before the selling season*, and liquidating any surplus the right way *afterwards*. The former is an issue of incentives induced by the wholesale pricing and is the predominant focus of the extant literature on return policies; the latter concerns logistics and comparative advantage in salvage, whose consideration appears to be unique to this study. A return policy may offer the leverage to affect the correct system inventory, but forces the destiny of any overstock. If salvage by the manufacturer is less lucrative for the system when all handling costs are properly considered, no return policy can achieve both conditions simultaneously.

Proposition 2(i) describes when both classes of inefficiency can be jointly overcome by a return policy. Under the stated conditions, results even stronger than Pasternack's apply in that a broader set of policies can be rationalized (as in part (i.b)), *but only if the economics of product handling are properly acknowledged*. Equation (9) is analogous to Pasternack's equation (11), except that the return rebate is reduced by the retail handling cost, and the manufacturer's salvage value is offset by the handling cost on both ends. If $t_R$ is positive, for a given return rebate the manufacturer must offer a wholesale price lower than Pasternack's recommendation, or a higher rebate for a given wholesale price[5]. Some such concession is imperative since any handling cost increases the retailer's reluctance to return product, thus depressing the initial order. Of course, the higher the $t_R$, the lower the likelihood that $s_R \leq s_M - t_R - t_M$ in the first place.

If a return policy is able to coordinate the channel, increasing the return rebate (up to its maximum allowed value of $p + g_R + t_R$) actually *benefits the manufacturer*. This is possible because the wholesale price is raised in conjunction (i.e., $\bar{w}(b)$ is increasing in $b$), and even extends to the case in which the manufacturer subsidizes the handling cost on returns, as in part (i.b). This coordination method remains invariant to the statistical properties of market demand uncertainty, suggesting applicability to a broad range of product classes and reducing the informational requirements for implementation.

Identification of the unique channel-coordinating return policy that will emerge in equilibrium is straightforward given our assumptions. Regardless of which party is the channel captain, there is always an economic incentive to coordinate the channel. The return policy gives the captain the means to grant the other firm the absolute minimum expected profit required for participation, and keep the remaining efficiency gains. Parts (i.d) and (i.e) of the Proposition make this explicit. Of course, in reality either party may have strategic reasons for allowing the other to earn more than its minimum, which is also attainable under this policy.

In summary, we have shown that when returns require a cost of handling or the channel partners have different salvage capabilities, existing wisdom about return policies generalizes only under certain conditions. When the manufacturer has the economic advantage in liquidating overstock, return policies are even more powerful than previously suggested, in the sense that full returns at either partial or full credit can achieve the desired goals. There is then no reason to consider any other channel policy, at least within this common modeling paradigm. But if the retailer has the liquidation advantage (which may often occur), then return policies fall in stature. In such a case, is there an alternative that can overcome incentive-based inefficiencies (double marginalization and externality vis-a-vis goodwill loss for retail stockouts) without the costs of physically relocating goods and using an inferior method of salvage? This appears to provide at least part of the industrial motive for the use of markdown money, which we analyze next.

## 4. Markdown money

In this section we will focus on the ramifications of using markdown money in a retail channel. The initial analysis will use the framework of the previous sections to allow comparison to existing literature. Here retail price will be treated as exogenous. We will then provide a formulation in which the retailer's pricing strategy may be studied. Certain conclusions will be obtained analytically, while others will derive from a subsequent numerical study.

### 4.1. Markdown money with fixed retail price

When the manufacturer has the liquidation advantage (i.e., $s_R \leq s_M - t_R - t_M$), we already possess a channel policy that Pareto-dominates any other, provided that handling costs and salvage values are properly acknowledged (cf. Proposition 2). So at this point we focus on the case of $s_R > s_M - t_R - t_M$, for which we know by Proposition 1 that channel-optimality requires $R = 0$ and $Q = F^{-1}((p + g - c)/(p + g - s_R))$, and by Proposition 2 that no return policy is consistent with this outcome.

We model a markdown money policy as an ordered pair $(w, m)$, where $w$ is the wholesale price as before and $m$ is the allowance paid by the manufacturer to the retailer to compensate for each unit left over at the end of the season[6]. The retailer continues to own any overstock and therefore may keep all funds generated by liquidation. While administering this program is not free, we assume that any costs not already factored into $s_R$ are negligible relative to those associated with the physical return of goods. The approach sets $R = 0$ by design, i.e., no returns are allowed. Both types of policies could conceivably coexist in practice, but in our simple framework the retailer will dispose of overstock entirely one way (whichever recovers more per unit). Specifically, the retailer will return all overstock if and only if $b - t_R > s_R + m$. So $R > 0$ and $m > 0$ are incompatible. Another requirement is $s_R + m < p$, preventing the retailer from buying product for the express purpose of collecting markdown money.

As before, we begin by stating the expected profits for the retailer and manufacturer, which we denote as $\pi_{R,mark}$ and $\pi_{M,mark}$, respectively. The following forms follow naturally by analogy to equations (6) and (8):

$$\pi_{R,mark} \equiv -Qw + \int_0^Q [px + (Q - x)(s_R + m)] f(x)dx + \int_Q^\infty [pQ - (x - Q) g_R] f(x)dx \tag{10}$$

$$\pi_{M,mark} \equiv Q(w - c) - \int_0^Q m(Q - x) f(x)dx - \int_Q^\infty (x - Q) g_M f(x)dx \tag{11}$$

For a given $(w, m)$ the retailer will choose $Q$ to maximize $\pi_{R,mark}$. The solution, obtainable by standard optimization methods, will be denoted as $\hat{Q}_{mark}$. It has the following value:

$$\hat{Q}_{mark} = F^{-1}\left(\frac{p + g_R - w}{p + g_R - s_R - m}\right) \tag{12}$$

When $m = 0$ (no markdown allowance, no return policy), this order is inefficiently low.

We consider two scenarios. The first isolates the effect of markdown money when the wholesale price is held fixed. The point here is not necessarily that such a decision structure would ever arise, but that studying this case will suggest whether markdown money is unequivocally oppressive to the manufacturer when all else is equal. The second allows both

$w$ and $m$ to be jointly adjusted. The outcomes are presented in Propositions 3 and 4, respectively.

**PROPOSITION 3.** *The use of a markdown money policy has the following implications when the wholesale price (w) is held fixed:*

*(i) For any wholesale price, increasing the markdown allowance always benefits the retailer.*

*(ii) For any wholesale price, there exist parameter combinations such that the manufacturer prefers to unilaterally increase the markdown allowance. The general condition for this is*

$$\frac{(p + g - s_R)(p + g_R - w)[F(Q^*) - F(\hat{Q}_{mark})]}{(p + g_R - s_R - m)^2 f((p + g_R - w)/(p + g_R - s_R - m))} > \int_0^{\hat{Q}_{mark}} (\hat{Q}_{mark} - x) f(x) dx \quad (13)$$

■

**PROPOSITION 3(i)** is intuitive since markdown money simply subsidizes the retailer for overstock. Indeed, Iyer and Bergen (1997) posited this to be a way to compensate a retailer for costs incurred elsewhere, although they did not formally model this. Part (ii) is somewhat surprising, since popular wisdom characterizes this practice as a way by which retailers abuse (typically weaker) manufacturers, to the extent that some retailers are thought to view markdown money as a "profit center" (e.g., Leccese 1993; Ryan 1996; Black 1997; Gellers *et al.*. 1997; Ryan 1998). On the other hand, while a direct cost to the manufacturer, markdown money also increases the manufacturer's sales (i.e., the retailer's order), so that a net positive profit impact should not be inconceivable. Unfortunately, equation (13) is a complex function of the cost parameters and distribution of demand that does not yield a simple economic interpretation. However, it can easily be evaluated for any specific set of parameters. Moreover, we can identify scenarios in which (13) holds, for instance when $m$ is small and $g_M$ is sufficiently large[7]. One way to rationalize this example is to view $g_M$ as a proxy for the manufacturer's future profits that will follow from a current sale[8]. Thus the manufacturer may be able to benefit in the long run by offering the markdown money necessary to penetrate the retailer's product offering in the short run (although the amount offered will not necessarily be the retailer's ideal).

Such logic would likely be most compelling to weaker manufacturers, who have little control over $w$ in the near term but hope to remedy this by growing market share. According to Moin (1995) one executive in apparel retailing has noted, "Stores won't ask Chanel, but will tell newer or younger designers, "We'll put your line in 12 stores, but give us a guaranteed sell-through of 65 percent at regular price and with the remaining 35 percent that's marked down, pay for the difference.' The bigger the chain, the worse it is. . ." "The ability of a designer firm to resist the markdown request is a function of their strength," said consultant Emanuel Weintraub. "Strong brands with impenetrable strength—the Hilfigers, the Nauticas; top, sizzling brands, they call the shots." A related scenario is when the retailer is reluctant to make a new season's purchase until the previous season's product has been cleared off the shelves, which markdown money helps expedite (Leccese 1993; Hungerford 1999). Here $g_M$ has a connotation of opportunity cost for the manufacturer. The next section will demonstrate numerically that this is but one case in which both parties can benefit from the introduction of markdown money.

Next we allow one party to dictate both parameters, examining in Proposition 4 the prospects for channel coordination and the impact on each party's expected profits.

**PROPOSITION 4.** *The use of a markdown money policy has the following implications when both the wholesale price* ($w$) *and the markdown allowance* ($m$) *are jointly set by a single party: (i) If the retailer has the liquidation advantage* (*i.e.,* $s_R > s_M - t_R - t_M$), *the channel can be coordinated with any of a continuum of markdown money policies of the form* ($\tilde{w}$ *(m), m*), where

$$\tilde{w}(m) \equiv p + g_R - \left(\frac{p + g - c}{p + g - s_R}\right)(p + g_R - s_R - m) \tag{14}$$

*(ii) For a given channel-coordinating markdown money policy, which will be uniquely determined by the value of m and equation* (14), *the expected profits for the two parties are*

$$\tilde{\pi}_{R,mark} \equiv (p - s_R - m) \int_0^{Q*} xf(x)dx - g_R \int_{Q*}^{\infty} xf(x)dx$$

$$\tilde{\pi}_{M,mark} \equiv m \int_0^{Q*} xf(x)dx - g_M \int_{Q*}^{\infty} xf(x)dx$$

*so that increasing the markdown allowance benefits the manufacturer at the retailer's expense.*

*(iii) When the manufacturer is the channel captain (Stackelberg leader with regard to the channel policy), the equilibrium will be the markdown money policy uniquely specified by*

$$m = p - s_R - \frac{V_R + g_R \int_{Q*}^{\infty} xf(x)dx}{\int_0^{Q*} xf(x)dx}$$

*with corresponding expected profits of*

$$\pi_{R,mark} = V_R \pi_{M,mark} = \pi_T^* - V_R \geq V_M$$

*(iv) When the retailer is the channel captain, the equilibrium will be the markdown money policy uniquely specified by*

$$m = \frac{V_M + g_M \int_{Q^*}^{\infty} x f(x) dx}{\int_0^{Q^*} x f(x) dx}$$

*with corresponding expected profits of*

$$\pi_{R,mark} = \pi_T^* - V_M \geq V_R \pi_{M,mark} = V_M$$

■

By Proposition 4(i), markdown money can induce the retailer to order the channel-optimal inventory. By design, all liquidation of surplus is performed by the retailer, capturing the superior salvage value and avoiding the return-related handling costs. Part (ii) reports a property similar to that obtained for channel-coordinating return policies: an action that favors the retailer when the wholesale price is *fixed* actually benefits the manufacturer when the wholesale price *can be appropriately increased*. In fact, part (ii) means that when the retailer has the advantage in recovering value from overstock, markdown money can dominate any alternative, including any return policy. And this approach is just as powerful as return policies in that ability to coordinate the channel does not depend on the extent of market demand uncertainty. Parts (iii) and (iv) are analogous to parts (i.d) and (i.e) of Proposition 2 in relating how strategic power in the channel will influence the outcome.

A novel insight of this analysis is the desirability of divorcing the task of aligning the incentives from the management of overstock, a point that would be irrelevant under the cost assumptions of the existing literature. We will see later that the penalty for not properly accounting for all these relevant costs may be substantial.

### 4.2. Markdown money with retail pricing

To illuminate the potential effect of markdown money on retail pricing behavior, we generalize this model to treat $p$ as a decision variable. In the interest of mathematical tractability, we suppose the market demand $X$ to depend on $p$ according to $X \equiv y(p) \cdot N$, where $y(p) \equiv \alpha - \beta p$ and $N$ is uniformly distributed on the interval $[0, 2\mu]$. This model requires $\alpha, \mu > 0$ and $\beta \geq 0$. This multiplicative form is a common way to model price-sensitive and stochastic demand (cf. Karlin and Carr 1962; Gallego and van Ryzin 1994; Emmons and Gilbert 1998; Petruzzi and Dada 1999). For reasons described earlier, we continue to represent the retailer's prospects for liquidating overstock with the exogenous salvage price $s_R$. To simplify calculations, we also drop the goodwill effects, i.e., $g_M = g_R = 0$.

Using standard techniques, with sufficient effort one can compute the retailer's profit-maximizing price and order quantity for a given set of environmental and markdown money parameters. These are, respectively,

$$\hat{p}_{mark} = \frac{3}{4}(s_R + m) + \frac{\alpha + \sqrt{(\alpha - (s_R + m)\beta)(\alpha - 9(s_R + m)\beta + 8\beta w)}}{4\beta}$$

$$\hat{Q}_{mark} = 2\mu(\alpha - \beta\hat{p}_{mark})\left(\frac{\hat{p}_{mark} - w}{\hat{p}_{mark} - s_R - m}\right)$$

These expressions suggest the effect of the channel policy on the retailer's decision-making and the equilibrium outcome, as summarized in Proposition 5.

**PROPOSITION 5.** *For the stated price-sensitive form of stochastic demand ($X \equiv y(p) \cdot N$, where $y(p) \equiv \alpha - \beta p$, and $N$ is uniformly distributed on the interval $[0, 2\mu]$), and assuming zero goodwill losses for retail stockouts (i.e., $g_M = g_R = 0$):*

*(i) When the markdown allowance (m) is held constant, increasing the wholesale price (w) increases the retail price and decreases the retailer's order quantity.*
*(ii) When the wholesale price is held constant, increasing the markdown allowance decreases the retail price, but has an indeterminate effect on the retailer's order quantity.*
*(iii) If the retailer is the channel captain with regards to the channel policy and the manufacturer's reservation profit $V_M$ is zero, channel-coordination will occur in equilibrium with $w = c$ and $m = 0$.*
*(iv) If the manufacturer is the channel captain with regards to the channel policy or $V_M > 0$, the equilibrium outcome will not coordinate the channel.* ■

The results stated in part (i) are intuitive. A main implication is that the demand directly faced by the manufacturer (i.e., the retailer's order) is decreasing in the price charged to the customer. The model's validity would be questionable were this not to be true.

Part (ii) is also reasonable, but requires additional explanation. All else equal, markdown money buttresses the retailer's margins. This allows the retailer to price lower than it would otherwise, and consequently increase the size of its market (stochastically). However, whether this yields any net benefit for the manufacturer is unclear. This could only be possible if the retailer's responds to the enlarged market by ordering more from the manufacturer. Certainly, one would think that this must be the case. After all, markdown money only actually makes a difference to the retailer when demand turns out to be less than the retailer's inventory, and lowering the inventory position would *reduce* the likelihood of that occurrence. However, this ignores the fact that with stochastic demand, overstock scenarios will still occur with some probability and the increase in markdown money paid in those scenarios contributes positively to the retailer's expected profit. Another confounding factor is the following well-known insight from the newsvendor framework: a decrease in the unit profit margin (which happens since the retail price decreases with the markdown allowance) reduces the penalty for understocking, which applies downward pressure on the optimal inventory position. Indeed, even with the simplifying demand model used here, the net effect of markdown money on the order quantity is indeterminate in sign. Numerical analysis suggests that the relationship is generally positive under most conditions. However, based on the preceding discussion we should not expect this to be uniformly true. Note further than even if markdown money were to always increase the retailer's order, this alone would not guarantee that manufacturer a net benefit, since the markdown money expenditures could offset the increase in wholesale revenue.

Parts (iii) and (iv) discuss the implications for channel efficiency. These results are largely consistent with existing literature, especially regarding double marginalization. Setting $w = c$ and $m = 0$ would allow the retailer to properly perceive the economics of the entire channel, and therefore would result in channel-coordinating choices for the retail price and quantity. However, this would leave the manufacturer with zero profit, and would therefore be sustainable in equilibrium only if the retailer is the channel captain and the manufacturer's reservation profit is zero. If either of these conditions does not hold, $w > c$ would be required, causing double marginalization. Consequently, the system as a whole could not achieve the maximum expected profit, although one of the individual parties may still be better off for it. Further insight into the effects on profitability will be provided through the numerical analysis of the next section.

## 5. Numerical illustration

This section presents numerical analysis to corroborate and supplement the earlier developments. The progression here will mirror that of the previous section. In the first stream of investigation the retail price will be treated as exogenous, so as to allow comparison of results to existing literature. The second stream will incorporate the retailer's pricing behavior.

### *5.1. Markdown money with a fixed retail price*

To enable closed forms for decisions and profits (omitted for space considerations), we consider market demand that is uniform over the domain $[\mu - \delta, \mu + \delta]$, although all results have been replicated for normally distributed demand. Unless otherwise noted, the analysis uses financial parameters $\{p = \$30, c = \$10, s_R = \$5, s_M = \$9, t_R = \$2, t_M = 0, g_R = 0, g_M = 0\}$ and demand parameters of $\{\mu = 100, \delta = 100\}$, although the properties illustrated are easily reproducible for fairly arbitrary parameter combinations. In this particular scenario the manufacturer has superior options for liquidating overstock (since $s_M > s_R$). However, to exploit this would entail physically returning the product to the manufacturer, thus imposing a handling cost on the retailer. In every parameter combination considered the channel-optimal customer service level (i.e., probability of avoiding stockout) exceeds 85%, which is consistent with managerial goals in many retail industries.

As a point of reference, Figure 1 illustrates the outcome for each party and the sources of inefficiency when the distribution policy consists simply of a per-unit wholesale price.

This reports a well-known property of such systems: the retailer always prefers a lower wholesale price while the manufacturer does not necessarily prefer a higher one (cf. Lariviere and Porteus 1998). Increasing the wholesale price increases the manufacturer's margin per unit, but the concomitant curtailment of the retailer's purchase size may outweigh this benefit. Under our assumptions, the independently managed channel is inefficient for the reasons highlighted by Proposition 1: double marginalization, the failure of the retailer to

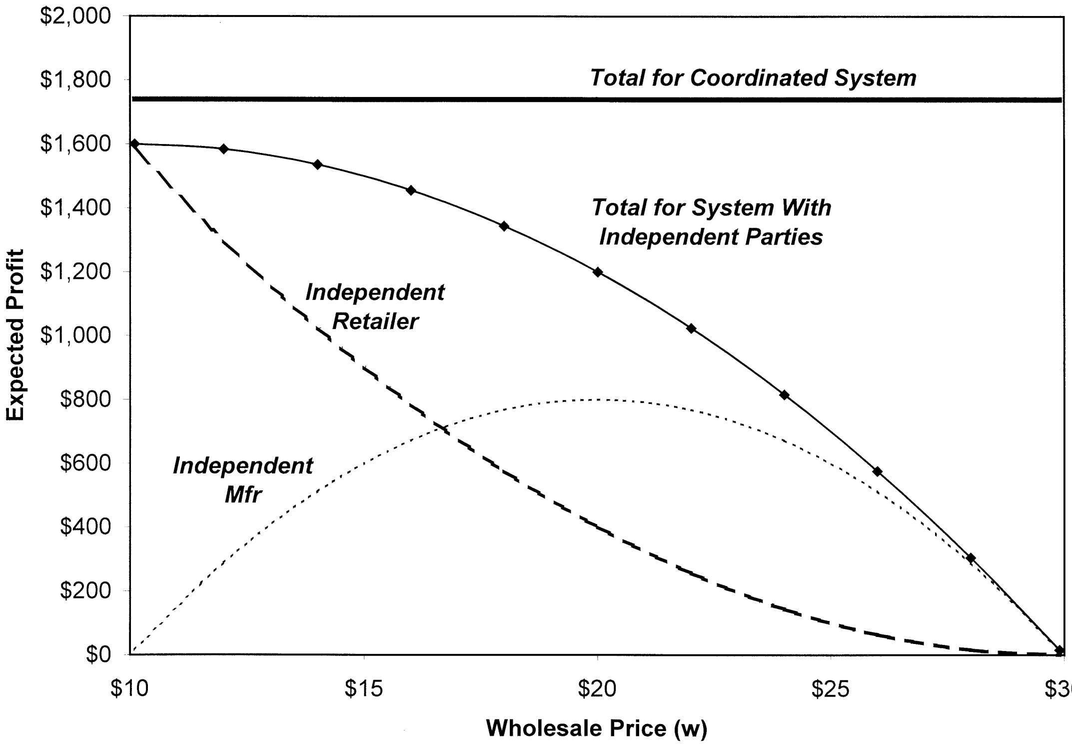


Fig. 1. Profitability under a channel policy with no provision for overstock.

internalize the manufacturer's goodwill loss, and the suboptimal liquidation of overstock. Because the parameter values indicate the channel to be better off when overstock is liquidated by the manufacturer, Proposition 2 dictates that a full-return policy that properly accounts for handling costs can simultaneously address the incentive and logistical inefficiencies, which would eliminate the gap between the top two curves in Figure 1. Furthermore, such a policy is viable as it can allocate the profits between the channel partners arbitrarily. The specific split of profit would depend on the channel leadership structure.

Suppose instead that $t_R = \$5$, so that the cost of sending retail overstock back up the channel favors liquidation by the retailer. Figure 2 illustrates how markdown money might be mutually preferable to the wholesale-price-only scenario. Here the wholesale price is fixed at $20, which is what the manufacturer would choose to maximize its own expected profit in the latter setting (cf. Figure 1). The markdown allowance is then varied.

Figure 2 provides an example of the dynamics described in Proposition 3, in that the manufacturer strictly prefers to unilaterally offer some markdown money (in this case up to as much as $m = \$8.33$ per unit). This also illustrates that for the given fixed wholesale price the channel can be completely coordinated with $m = \$12.5$, which is consistent with equation (14).

In Figure 3 system profits are presented as a function of the retailer's handling cost for returns as a fraction of the retail price (i.e., $t_R/p$). This best addresses the primary motivation of this research, directly comparing the various methods that have been discussed.

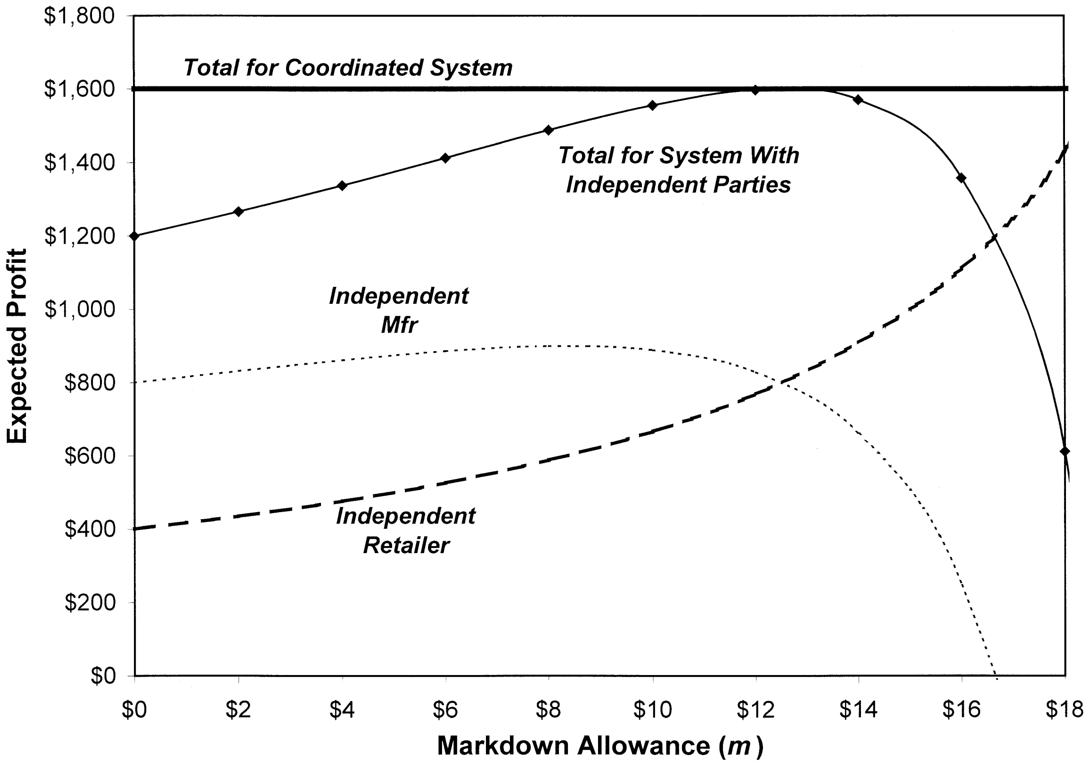


Fig. 2. Effect of markdown money on expected profit, with fixed wholesale price.

Curves A and C indicate that low handling cost (here $t_R/p < 13.3\%$) favors the use of a return policy while high handling cost recommends markdown money, as analytically determined by Propositions 2 and 4. As this cost increases, the return policy is increasingly disfavored, eventually becoming less efficient than even the wholesale-price-only scheme associated with curve B[9]. Since each channel-coordinating scheme allows arbitrary allocation of profits, the upper envelope of A and C can be attained with no resistance from either channel member.

Curves D and E underscore the significance of our extensions to Pasternack's analysis. These depict the result when the channel captain designs a full-return policy that *it believes to be* channel-coordinating, but has erroneously ignored the handling costs for returns. Since the expected system profit under these conditions does depend on the wholesale price and return rebate, which in turn depend on the leadership structure in the channel, we present two cases. Curve D describes the outcome for a low return rebate (which is what the retailer would choose as channel captain), and curve E results from a return rebate close to the upper bound allowed by Pasternack (which the manufacturer would choose). The region between the two curves spans the prospects for intermediate values of these parameters.

The key insight is that the loss in efficiency from the simple act of ignoring handling costs can be quite significant. The effect is the composite of two factors: (1) handling costs render a return policy logistically more costly, and (2) handling costs depress the retailer's order

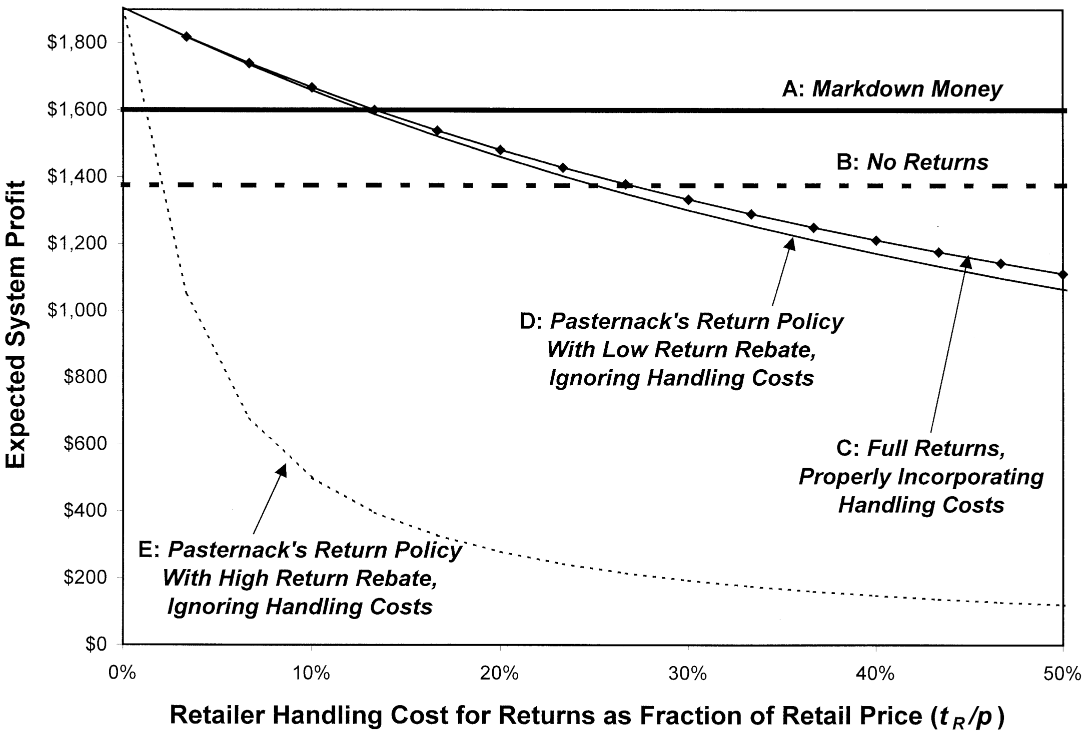


Fig. 3. Dependence of channel policy performance on handling cost for returns.

away from the system-optimal level. When the handling cost for returns is significant, there is some value to be recovered by properly adjusting the design of the return policy, and even more by using a *different channel policy altogether*.

Figure 4 examines the effect of demand uncertainty, comparing how the system performance under each of the policies in Figure 3 varies with the standard deviation of market demand. Under the stated assumptions, this standard deviation has the value $\delta/\sqrt{3}$. We have assumed $t_R = \$4$, for which markdown money and a properly designed full return policy perform identically. Increasing $t_R$ would magnify the effect.

This suggests that while increasing demand uncertainty naturally erodes system performance regardless of the channel policy, the magnitude of inefficiency can be exacerbated substantially by ignoring the handling costs for returns.

## *5.2. Markdown money with retail pricing*

Proposition 5 provided some analytical results for the case in which retail pricing becomes a decision variable. Here we illustrate some properties of that extended model.

To specify the price-sensitivity of market demand, we assume $\alpha = 30$ and $\beta = 0.8$, so that $y(p) = 30 - 0.8p$. That is, the demand random variable is $X = (30 - 0.8p)N$, where $N$ is uniformly distributed on [0, 200]. We retain the base-case parameter values from earlier.

To parallel the previous analysis, in particular Figure 2, we first fix the wholesale price (at

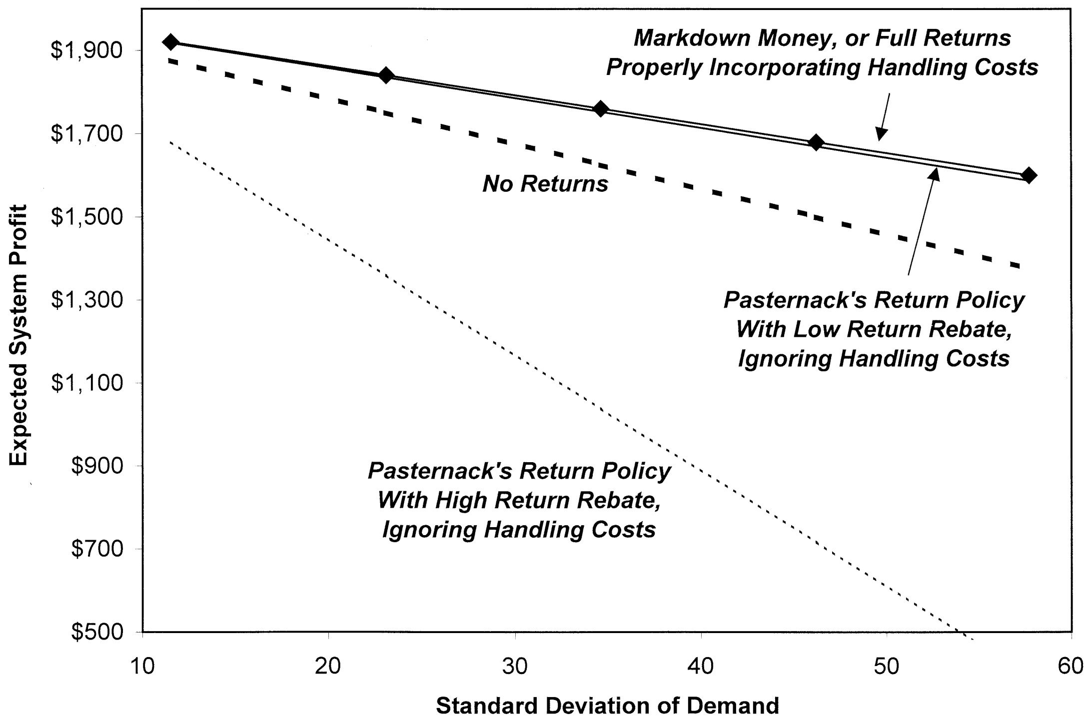


Fig. 4. Dependence of channel policy performance on demand uncertainty.

$w = \$20$) and then illustrate the effect of varying $m$. Figure 5 shows how markdown money influences the retailer's pricing and inventory strategies. That the retail price is decreasing in $m$ was proven analytically in Proposition 5. Here we see that the markdown money induces the retailer to order more, which must be the case in at least some circumstances for the manufacturer to have any hope of benefiting from this policy. Figure 6 shows the corresponding expected profits of each party, and their sum. The trends depicted here parallel those that arose in Figure 2 when retail price was held fixed. Most significant is the impact of markdown money on the manufacturer. Even without any way to offset the expected out-of-pocket cost required, the manufacturer would still prefer to offer such a policy, ideally setting $m = \$9.88$. This means the retailer will pay a wholesale cost of \$20 per unit up front, but for each unit unsold at the season's end can collect \$9.88 back from the manufacturer in addition to the \$5 liquidation value. The increase in the manufacturer's profit is due to an increase in the inventory the retailer makes available for sale, as seen in Figure 5. Figure 6 also shows that the retailer would like as high a markdown allowance as possible, as one would expect. These figures do not depend on the channel leadership structure, since they simply examine the effect of varying $m$ (when $p$ and $Q$ are set optimally by the retailer for a given $m$).

Finally, we consider the case in which $w$ and $m$ are jointly set by the channel captain to maximize its own expected profit subject to the condition that the other party must expect to earn its reservation profit. For simplicity we assume that $V_M = V_R = 0$. Figures 7 and 8 treat

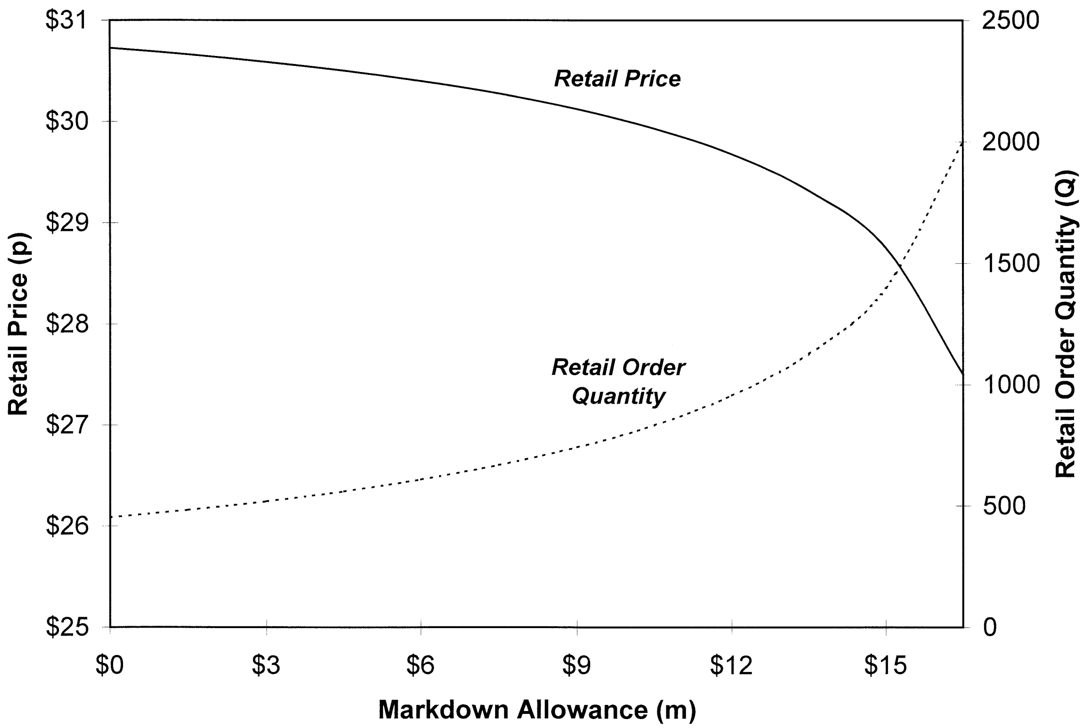


Fig. 5. Effect of markdown money on retail pricing and inventory strategy, with fixed wholesale price.

the manufacturer as channel captain, and Figures 9 and 10 give this status to the retailer. Each point in these curves entails finding the optimal $m$ for the particular $w$ (through the process suggested by Figure 6).

Figures 7 and 8 confirm that even if the channel relationship is entirely under the manufacturer's control, there may still be a place for markdown money. As was the case when retail price was treated as fixed, this is possible because the wholesale price will be increased in conjunction. However, here we can report the effect on the retailer's pricing as well. We find that increasing the wholesale price tends to increase the retail price and decrease the retailer's inventory position, as would be expected. However, the use of markdown money allows the manufacturer to blunt the retailer's sensitivity to the wholesale price increase, as seen in the leveling of the retail order quantity curve in Figure 7. This provides support to the manufacturer's sales revenue without greatly compromising the desire to have inventory in the channel. The ultimate equilibrium outcome, corresponding to the peak of the manufacturer's expected profit curve in Figure 8, involves a substantial markdown allowance. However, this is detrimental to the retailer and total channel efficiency.

Comparing Figures 9 and 10 to Figures 7 and 8 demonstrates the strong influence of the balance of power in the channel. In Figure 9, even when the retailer controls the channel policy, increases in markdown money still must be accompanied by increases in the wholesale price. This is because the retailer does not have absolute power to abuse the

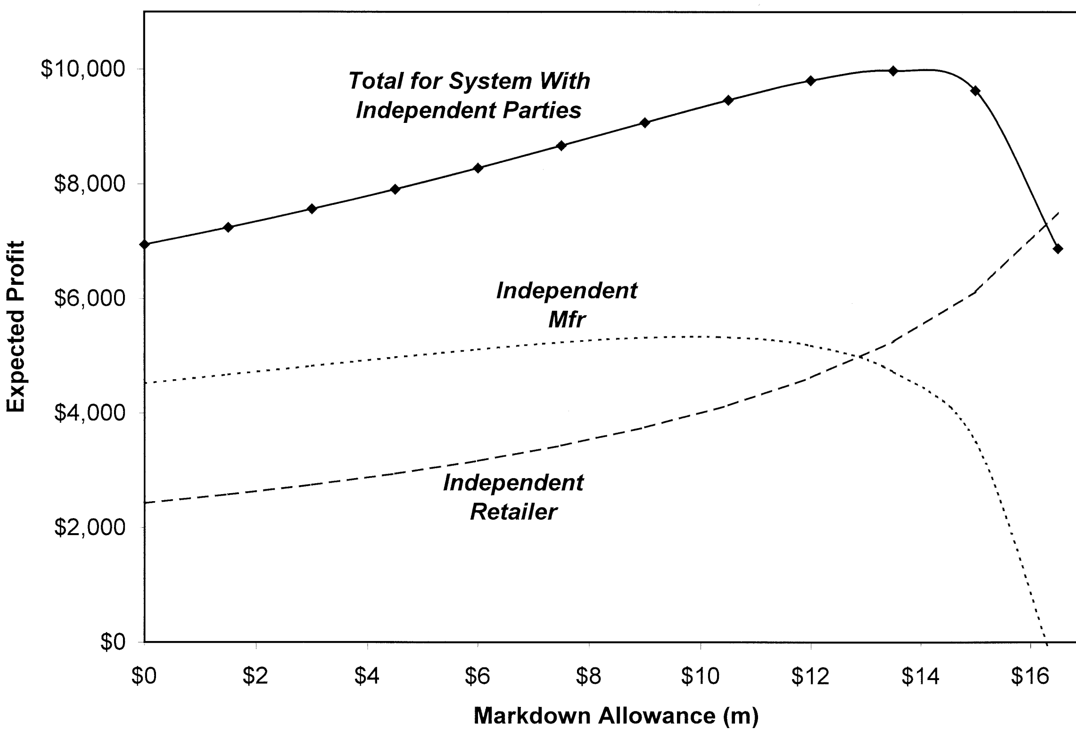


Fig. 6. Effect of markdown money on profitability.

manufacturer, as reflected in the model by the condition that the manufacturer's expected profit must not drop beneath the reservation value $V_M$. As the wholesale price is increased, the retailer does charge a bit more for the product, which was also seen in Figure 7. However, here the inventory position increases as well, which occurs because for any $w$ the retailer implements a much higher markdown allowance than the manufacturer would. Thusly insured against overstock, the retailer increases inventory even as expected demand drops due to the retail price increase. The retailer can extract all the value from the channel using this mechanism, as reflected in Figure 10 by the manufacturer's zero level of expected profit. However, the retailer's ideal policy for the assumed setting actually has a low wholesale price and *low markdown allowance*. This is consistent with the fixed-retail-price setting described by Proposition 4. It appears that the retailer derives greater benefit from a low wholesale price on *every* unit procured than a large markdown allowance that it collects only in overstock scenarios. Indeed, the retailer has the ability to control the magnitude of the overstocking problem via its pricing strategy in this model, and any number of additional tactics (e.g., advertising, sales effort, physical placement in the store, etc.) in reality. We can conclude that the general lack of strategic power is what hurts the manufacturer here, not the amount of markdown money the retailer would demand.

The surprising theme that recurs throughout our theoretical and numerical investigation is that markdown money policies are not simply the dictates of a powerful retailer. Instead, they can derive from the interests of manufacturers seeking to insure that adequate inventories are

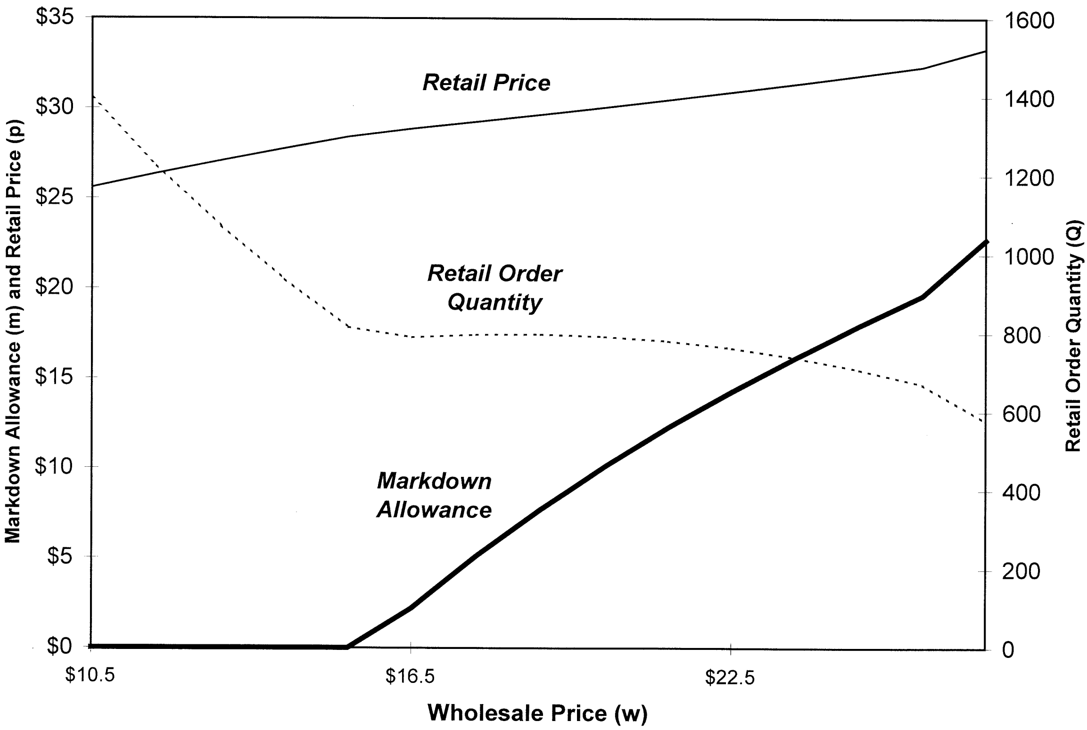


Fig. 7. Channel decisions when manufacturer sets wholesale price and markdown allowance.

held in the channel. And in fact, there may be circumstances under which manufacturers may have a greater desire to implement such policies than their retail partners. Indeed, the Procter & Gamble initiative would be difficult to rationalize otherwise.

## 6. Discussion and directions for future research

In areas mentioned throughout this article and more, this model is an abstraction of reality. The preceding development provides a point of departure for discussing other issues associated with the industrial usage of these channel policies.

In reality return policies and markdown money both are just a few of the potential terms of trade that enter the manufacturer-retailer conversation at the time initial purchase commitments are made. Others include provisions for sharing of marketing costs, price protection, and various forms of discounts (e.g., for prompt payment). Retailers are likely to have a target gross margin for individual product categories (usually set by a Corporate Merchandiser responsible for the category), and policies such as these serve as mechanisms for reaching the targets should sales outcomes disappoint. In practice the negotiators on both sides likely bargain using the terms of all these policies simultaneously. Moreover, the channel policies are commonly collectively reviewed on a quarterly basis, and also as the end of the selling season approaches. Each review provides an opportunity to fine-tune the policies in place, to execute upon any pre-established agreements, and to even reconsider

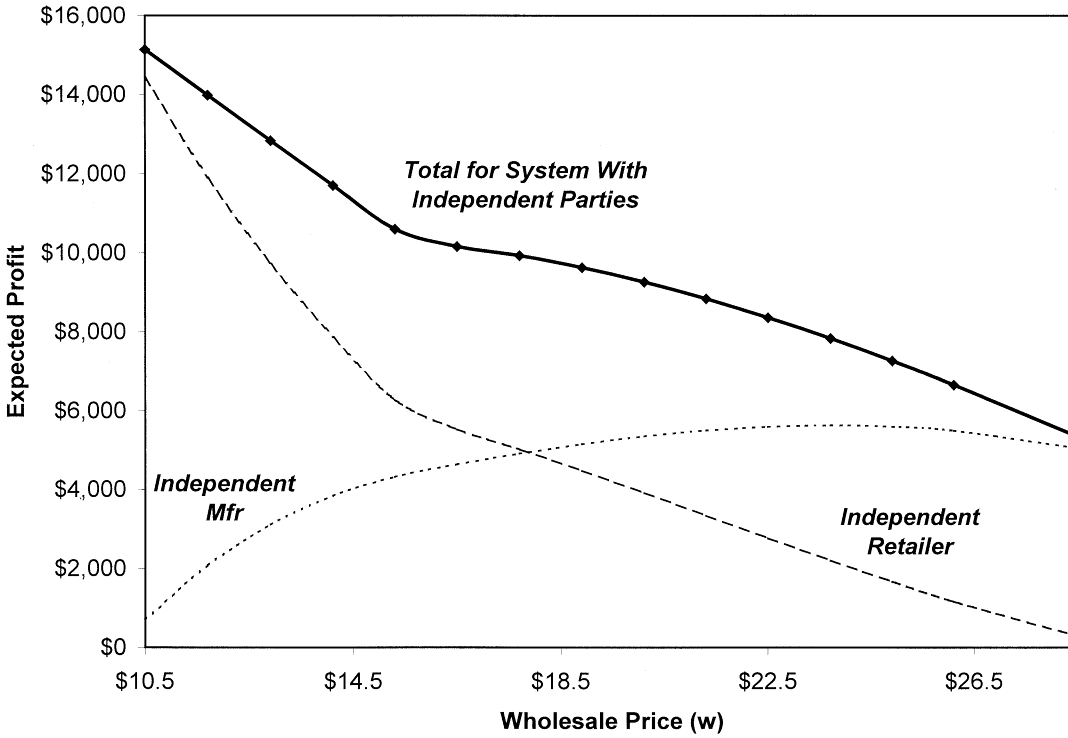


Fig. 8. Expected profits when manufacturer sets wholesale price and markdown allowance.

whether to continue the relationship at all. (Hungerford 1999, Bariquit 2000) These dimensions are not directly considered in our focused analysis.

In a similar vein, ideally a retailer's policies around the management of overstock would be designed jointly with the return privileges offered to end consumers. For instance, generous customer return policies create an inventory risk that a retailer would presumably like the manufacturer to help bear. Consumer returns have been modeled in the academic literature (e.g., Davis *et al.* 1995; Hess *et al.* 1996; Chu *et al.* 1998; Davis *et al.*1998) although existing works tend to take a single-firm perspective by focusing only on the retailer's market interface. The prevailing emphasis has been on modeling the consumers' need to experience the product before being able to fully assess the product's value, and enabling the retailer to accommodate legitimate customer concerns while guarding against opportunistic behavior. An area of future research would be to combine such a model with the channel framework described here.

New issues regarding channel policies can arise when there are multiple parties at either the retail or manufacturer level, which dyadic models do not directly embrace. For instance, such policies become just one dimension of the bidding process that competing parties undertake, and the outcome depends on the balance of power in the channel. This issue is addressed to some extent in our model's consideration of alternative channel leadership scenarios, which are essentially a reflection of the relative competitive conditions in the manufacturer and retailer sectors. Another issue that is unrepresented

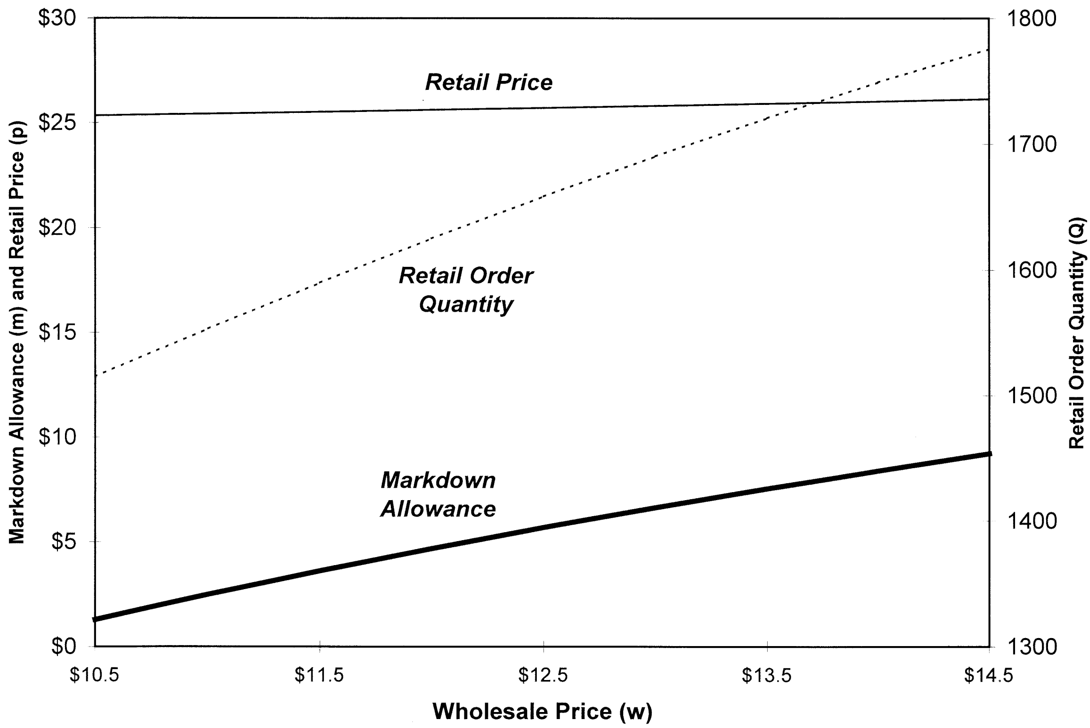


Fig. 9. Channel decisions when retailer sets wholesale price and markdown allowance.

by single-retailer models is the influence of inventory pooling on the design of a return policy. A manufacturer might be willing to offer more generous return policies across a portfolio of multiple retail firms since returns from one retailer have more prospects for retail sale elsewhere (provided that handling and logistics costs are not prohibitive). Markdown money would not enjoy the same effect, since the retailer retains ownership of the inventory. An interesting extension would be a model in which one retailer has access to a return policy or markdown money (perhaps at a higher wholesale price), while its competitor does not.

A number of other managerial issues must be considered in rationalizing the use of either policy. In particular, the determination of how best to handle overstock may be complicated by certain factors that are not easily quantifiable. These include the following:

- Markdown money increases the level of “clearance” activity of a manufacturer’s product in the retail store, and having this transpire just a few feet away from the roll-out of that manufacturer’s new offering can confuse customers and store personnel, and complicates the product transition process. Regarding P&G’s replacement of return privileges with markdown money for discontinued items, a spokeswoman for Wegmans Food Markets (Rochester, N.Y.) indicates, “As a result of it, we are probably not introducing new items as we once did.” Instead, the chain will wait until old products sell before bringing in new ones. This can create “holes” in a retailer’s product assortment, which hurts both channel partners (Klepacki 1998).

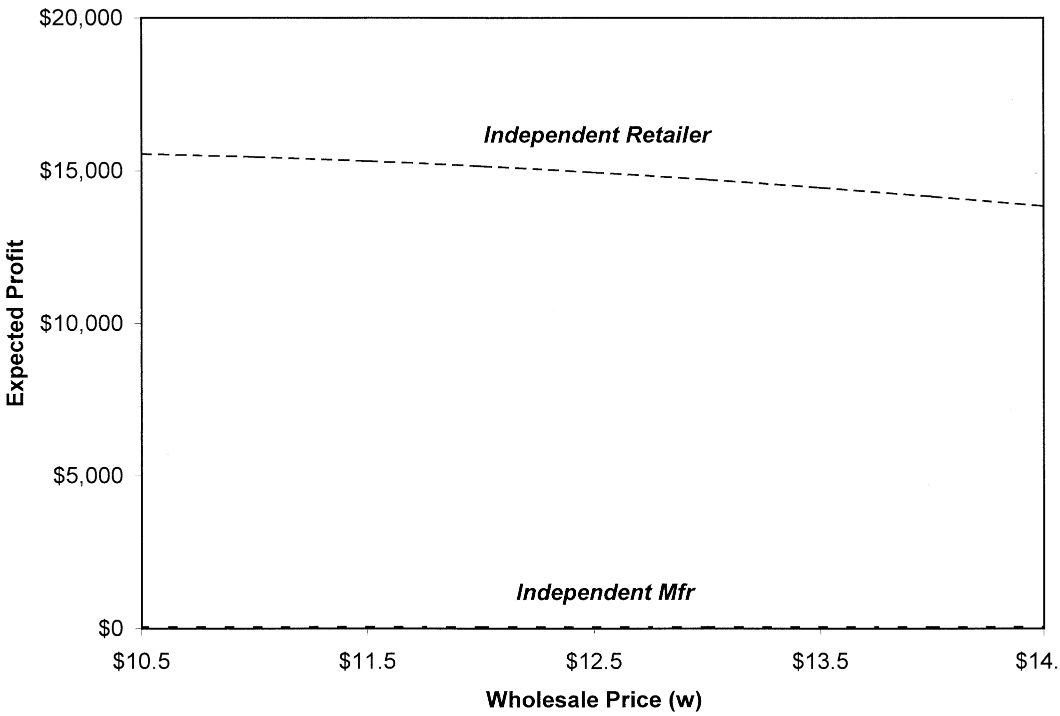


Fig. 10. Expected profits when retailer sets wholesale price and markdown allowance.

- A brand-protecting manufacturer might choose to pull back all retail overstock even if its own salvage prospects are inferior, so as to divert its product from the discount bin (cf. Padmanabhan and Png 1995). Alternatively, one could imagine such a manufacturer paying markdown money with a stipulation that the retailer will display the product through the end of the season without discounting, even though this might assure overstock. The motive would be to signal product quality and to condition customers against waiting for sales. However, this could be interpreted as "price-fixing," which raises some legal issues.
- On the other side of the channel, retailers' own performance metrics may implicitly favor one policy over the other. A high "sell-through" rate, which reflects items sold on discount but not returns to the manufacturer, is considered desirable (Parks 1996). In fact, this may be an implicit acknowledgment of the significance of the handling costs associated with returning product.
- Regardless of the underlying distribution of profits, the direction of cash flow suggested by such a system enjoys a favorable perception in the eyes of some retailers. One drugstore merchant finds this aspect of P&G's markdown money program superior to the return policy it supplanted, commenting, "At the end of 12 months, we can take the product that we have suddenly paid nothing for and still sell it. It is our product; they never ask for it back. And they give us full cost." (Klepacki 1998) Based on the preceding analysis, it is not inconceivable that P&G also benefits from this.

One retail executive sees the entire class of techniques as practices that ideally should exist primarily in the short-term while a lasting relationship is being built. They motivate the retailer not only to allocate shelf space to a manufacturer, but also to learn how to market the product, how to incorporate it into the product assortment and merchandising strategy, and so on. As this is accomplished, demand should increase and uncertainty about that demand should diminish, so that overstock becomes less a concern for both parties (Hungerford 1999). In taking such a view, this executive emphasizes the value of a "win-win" outcome, which is consistent with our analysis.

## 7. Conclusion

This article studies a manufacturer-retailer channel facing unknown demand. A well-known phenomenon is that when the wholesale relationship comprises only a per-unit price that strictly exceeds the manufacturing cost, the retailer's inventory strategy will not properly reflect the system's perception of overstock and understock costs. A number of researchers have advocated manufacturer return policies to remedy this misalignment of incentives, but none explain the reality that "markdown money" is sometimes paid to retailers expressly to avoid product returns.

In generalizing this literature our main conclusions are the following: (i) the proper design of a return policy must take into account any costs of product handling, especially in their influence on the retailer's behavior, (ii) a return policy may be inefficient if it entails liquidating any overstock in an inferior way, (iii) markdown money can coordinate the channel when a return policy cannot, (iv) unawareness of the issues differentiating these policies may result in a substantial loss of system performance, and (v) markdown money policies are not simply the dictates of a powerful retailer, but instead can derive from the interests of a manufacturer seeking to insure that adequate inventories are held in the channel.

## Appendix

**PROOF OF PROPOSITION 1.** For any given $Q$, $d\pi_T/dR = (s_R - (s_M - t_R - t_M))Q \cdot F((1 - R)Q)$. Since $Q$ and $F()$ are non-negative, the sign of $(s_R - (s_M - t_R - t_M))$ determines the direction of ascent with respect to $R$.(Second order conditions can easily be verified.) If $s_R = s_M - t_R - t_M$, the choice of $R$ is irrelevant as the net salvage value is the same no matter how the overstock is handled. In such a case parts (i) and (ii) will yield the same value of $Q^*$. Pasternack's scenario is one special case of this since he assumes $t_R = t_M = 0$ and $s_R = s_M$. ■

**PROOF OF PROPOSITION 2.** (i) If $s_R \leq s_M - t_R - t_M$, then $R^* = 1$ by Proposition 1, so that any return policy with $R < 1$ will automatically be system suboptimal. Anything less than a full return means that a non-zero portion of the overstock will be liquidated in an inferior way. Setting $R = 1$ leads to $\hat{Q}_{return} = F^{-1}((p + g_R - w)/(p + g_R - b + t_R))$. It is straightforward to show that a price couplet of $(\bar{w}(b), b)$ will achieve $\hat{Q}_{return} = Q^*$, proving part (a). The p expressions for the respective expected profits in part (c) follow directly. To show part (b), refer to the left boundary of the stated interval as $b'$. It is easily verifiable that $b' = \bar{w}(b')$. Then since $d\bar{w}(b)/db = (p + g - c)/(p + g - s_M + t_R + t_M) < 1$, $b > b'$ implies $b > \bar{w}(b)$ and $b < b'$ implies $b < \bar{w}(b)$. These price combinations continue to satisfy the required conditions, the most relevant being $\bar{w}(b) \geq b - t_r$. Regarding this, note that for any $b < p + g_R + t_R$, $\bar{w}(b) - (b - t_R) = (p + g_R + t_R - b)(c - (s_M - t_R - t_M))/(p + g - (s_M - t_R - t_M)) > 0$. The implication of this result is that Pasternack's Theorems 1 and 2 continue to hold, but his Theorem 3 is no longer true. Parts (d) and (e) are a direct result of the channel captain's incentive to do as well as possible by giving the other party as little as possible. The values of $b$ that will support this goal follow immediately from the profit expressions obtained in part (c).

(ii) If $s_R > s_M - t_R - t_M$, $R^* = 0$ by Proposition 1, so that any return policy with $R > 0$ will automatically be system suboptimal. This is because a non-zero portion of the overstock will be liquidated in an inferior way. The only hope is to set $R = 0$, but then (7) indicates that $\hat{Q}_{return} = F^{-1}((p + g_R - w)/(p + g_R - s_R))$, which is strictly less than $Q^*$ since $w > c$ (double marginalization) and $g_R \leq g$ (the retailer fails to internalize any goodwill loss incurred by the manufacturer). Hence, in this case Pasternack's Theorems 2 and 3 continue to hold, but the limitation described by his Theorem 1 is no longer true[10]. ■

**PROOF OF PROPOSITION 3.** By the Envelope Theorem (cf. Varian 1984), for any $m$, $d\pi_{R,mark}(\hat{Q}_{mark})/dm = d\pi_{R,mark}(Q)/dm\big|_{Q=\hat{Q}_{mark}} = \int_0^{\hat{Q}_{mark}} (\hat{Q}_{mark} - x) f(x) dx > 0$, proving part (i). Equation (13) in part (ii) is an explicit expression of the condition $d\pi_{M,mark}(\hat{Q}_{mark})/dm > 0$. ■

**PROOF OF PROPOSITION 4.** It is apparent from (12) and (14) that when $w = \tilde{w}(m)$, $\hat{Q}_{mark} = Q^*$, proving (i). Evaluating (10) and (11) at $w = \tilde{w}(m)$ delivers (ii). ■

**PROOF OF PROPOSITION 5.** The proof for part (i) is obvious from the form of $\hat{Q}_{mark}$.

For part (ii), we examine the relevant derivative, which can be computed to be

$$\frac{d\hat{p}_{mark}}{dm} = \frac{1}{4}\left(3 - \frac{5\alpha + 4\beta w - 9(s_R + m)\beta}{\sqrt{(\alpha - (s_R + m)\beta)(\alpha - 9(s_R + m)\beta + 8\beta w)}}\right)$$

The easiest way to show this to be uniformly negative is by contradiction. That is, suppose that there exists some parameter combination such that $d\hat{p}_{mark}/dm > 0$. It must then be the case that

$$3\sqrt{(\alpha - (s_R + m)\beta)(\alpha - 9(s_R + m)\beta + 8\beta w)} > 5\alpha + 4\beta w - 9(s_R + m)\beta$$

On squaring both sides of this (which does not affect the direction of the inequality since both sides are positive for allowable parameter combinations) and grouping terms, we find this to require that $16(\alpha - \beta w)^2 < 0$, which clearly can never be true. Hence, $d\hat{p}_{mark}/dm \leq 0$ for all allowable parameter choices.

To prove part (iii), note that the optimization problem faced by the channel as a whole is aligned with the retailer's only when $w = c$ and $m = 0$. However, this channel policy prevents the manufacturer from earning any profit, hence will be sustainable in equilibrium only if $V_M = 0$ (and we continue to assume the manufacturer will produce whatever the retailer orders). If $V_M > 0$ or the manufacturer has the strategic power to insist upon a positive expected profit, $w > c$ is required. This will undermine channel coordination, as stated in part (iv). ■

## Notes

1. The terms "markdown money" or "markdown allowance" describe a payment made by a manufacturer to a retailer per item that must be discounted for final clearance purposes.
2. Padmanabhan and Png (1997), Emmons and Gilbert (1998), and Webster and Weng (2000) make an even stronger assumption, requiring all overstock to be worthless. Kandel (1996) notes that asymmetry in liquidation options is likely, but does not provide a coordination mechanism for this case.
3. The assumption of a fixed market price is usually described as being the result of an extremely competitive environment or some manufacturer policy such as Resale Price Maintenance. Kandel (1996) provides another rationalization for this assumption: "Retail demand consists of *x* identical consumers with a known reservation price, *P*; each customer is willing to purchase at most one unit of this product. Clearly the retail price in this case will optimally be set to *P*."
4. This channel policy is perhaps the most natural base case to consider, and in Pasternack's framework the inefficiency is due to too small an order. This is because, relative to the system perspective, the retailer perceives too high a cost of overstock (obtaining the product at a markup relative to the production cost), and too low a cost of understock (receiving a profit per sale that is less than the value created for the system). This distortion is known as "double marginalization," a well-known cause of channel inefficiency that results from the existence of two separate entities within the channel (cf. Spengler 1950; Tirole 1988). Many of the contractual structures recently studied (cf. Tsay *et al.*, 1999) attempt to remedy some variant of this basic problem. The inefficiency is exacerbated if the manufacturer incurs goodwill loss on retail stockouts, since an independent retailer's order will not account for this.
5. This is true because $d\bar{w}/dt_R = -(p + g - c)(g_M + b + t_M - s_M)/(p + g - (s_M - t_R - t_M))^2 < 0$.
6. The markdown allowance is commonly stated as a percentage of the wholesale price. To allow comparison to established academic literature, we have chosen to measure all financial variables using absolute dollar figures. However, clearly the difference could be resolved with a simple change of variable, and none of the results would be affected. Also, the total payment is sometimes credited to the retailer's future purchases rather than rebated in cash. We will treat any credits as being equivalent to cash.

7. On the left side of (13), $(p + g - s_R)$ is unboundedly increasing in $g_M$ and $[F(Q^*) - F(\hat{Q}_{mark})]$ is positive and increasing in $g_M$, while the right side is invariant to this variable.
8. Pasternack did not elaborate on the importance of the manufacturer's goodwill loss for retail stockouts, and all other aforementioned research modeling return policies ignored this altogether. Our analysis demonstrates that $g_M$ can be a key determinant of channel incentives.
9. The position of curve B is a function of the wholesale price. For the sake of illustration, we have assumed $w = \$20$ as in Figure 2.
10. When $t_R = 0$ as Pasternack assumed, and $R = 1$, the definition of $b$' indicates that channel coordination via a full-credit/full-return contract would require $\bar{w}(b) = b - p + g_R$, which he disallowed for denying the retailer its reservation profit. This is the logic underlying his Theorem 1.

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