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Used goods, not used bads: Profitable secondary market sales for a durable goods channel

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Abstract The existing literature on channel coordination typically models markets where used goods are not sold, or are sold outside the standard channel. However, retailers routinely sell used goods for a profit in markets like textbooks. Further, such markets are characterized by a renewable consumer population over time, rather than the static consumer population often assumed in prior literature. We show that accounting for these market characteristics alters the optimal contract form as compared to the contracts derived in prior research. In particular, when new goods are sold in both the first and second periods of our model, the optimal contract differs from those in prior literature in that it can exhibit a negative fixed fee in the second period and requires contracting over the resale price in the second period. The model shows that the manufacturer makes higher profits from allowing used-good sales alongside new-good sales than from shutting down the retailer-profitable secondary market, and that unit sales expand with a profitable secondary market over those achievable without a secondary market. Furthermore, in contrast to previous investigations of durable goods markets that ignore the possibility of a retailer-profitable secondary market, we show conditions under which the manufacturer would optimally choose to sell *no new* goods in the second period, ceding the market entirely to the used-goods retailer. This research thus expands our knowledge of how durable goods markets work by incorporating the profitable operation of a retailer-run resale market.

Keywords Channels of distribution · Game theory · Durable goods · Used-goods markets · Channel coordination

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The sale of durable goods through a secondary market has significant impact on their consumption, production and distribution. Secondary markets arise for a variety of durable goods because there are consumers who value the used good more than its current owner. While some used-good transactions are completed without the benefit of an intermediary, retailers have facilitated the secondary market by buying and selling used goods, contributing to the rapid growth of secondary markets. For example, between 1993 and 2002 there was a 20% increase in the number of used-book dealers (Mehegan 2003).

When the secondary market is operated by the manufacturer's new-goods retailer, manufacturer and retailer incentives are not in alignment. From the manufacturer's point of view, higher first-period sales generate higher first-period profits, but also result in a greater quantity of used goods to compete with future new good sales, thereby diminishing subsequent manufacturer sales. For the retailer, on the other hand, higher first period sales lead to a cheaper supply of used goods and less reliance on the manufacturer as a source of future profits. The retailer also benefits from the addition of a substitute good (the used product) to its product line.

The issue of coordinating distribution channels by using multi-part tariffs has long been a topic of research. Previous research shows that a manufacturer can, under some conditions, earn the profits of an integrated channel and induce optimal marketing decisions through use of a standard two-part tariff strategy of charging the retailer a wholesale price equal to the marginal cost and extracting all rents from a positive fixed fee (see, for example, Jeuland and Shugan 1983; McGuire and Staelin 1983; Villas-Boas 1998). However, Desai et al. (2004) find that the two-part tariff with marginal cost pricing will not work for durable goods. They prove that if channel members can initially commit to a two-period contract, then the manufacturer will use a two-part tariff with wholesale prices *above* marginal cost for each period to maximize channel and manufacturer profits.

In contrast to previous work in the area, which assumes that the used market generates no profits for channel members (Desai et al. 2004), this paper models the channel for a durable good with an imperfect secondary market, endogenizing the retailer's decision to buy back used goods from consumers for profitable resale. Additionally, we assume a renewable market of consumers. In a renewable market, a new population of potential buyers arises each period. This assumption makes abundant sense in markets like that for college textbooks. For example, each semester, another crop of undergraduates needs to buy the introductory psychology textbook and the students who took introductory psychology the previous semester are no longer in the market for the textbook the next semester. We take explicit account of these two market characteristics—a renewable consumer population, and a profitable retail resale market—to address three main research questions:

1. How does the market structure for durable goods affect optimal channel contracts?
2. Can the first-best outcome be achieved when the retailer profitably operates a secondary market?

3. What are the sales and profit effects, of a retailer-operated secondary market relative to a scenario in which consumers must keep their goods as used?

We show that the simple contracts derived under other market assumptions in fact are no longer optimal in our market structure, but contracts like those in the textbook market are optimal. Specifically, in this market space, durable goods manufacturers offer more complex contracts than simple per-unit wholesale prices. For example, textbook publishers commonly have three elements in their contracts with retail booksellers: a per-unit wholesale price, a suggested retail price, and a flat charge for shipping.[1] Normally, the retailer pays a publisher-specified shipping cost. But with many titles for which used books are available to consumers, retailers receive free shipping for the order; this offer of free shipping shifts this fixed fee back to the publisher. This evidence supports our finding that, not only are multi-part tariffs with retail price maintenance optimal, but a tariff element can be a negative price (that is, a cost borne by the manufacturer).

Desai et al. (2004) find that a durable goods manufacturer can use a retailer as an intermediary to achieve the first-best outcome of a durable goods renter. However, our model shows that if the retailer operates a profitable secondary market, there are conditions under which the first-best outcome is unattainable (even with the additional contracting instruments). These conditions occur when production costs are high enough for the manufacturer to optimally choose to stop new good sales in the second period. More generally, this result illustrates the complex balance the manufacturer must maintain between the demand and cost sides of its problem when the retailer also makes profit-maximizing stocking and sales decisions.

In general, new-good manufacturers fear the availability of used goods because they create competition for new goods. The common belief is that this competition reduces a new-good manufacturer's sales and profits. Will Pesce, CEO of John Wiley & Sons publishers, blamed a quarterly decline in higher-education sales on used book sales (Mutter et al. 2004). Iizuka (2005) finds empirically that publishers revise editions more frequently as used-good sales increase. Previous literature has found that durability has a negative effect on a monopolist's profits when the population of buyers is non-renewable over time, suggesting that obsolescence has its benefits (Bulow 1982; Rust 1986; Waldman 1996). Hendel and Lizzeri (1999) find that a monopolist would prefer to change durability rather than close secondary markets. Other research has found that eliminating a secondary market is a profitable action when new and used goods are close substitutes (Liebowitz 1982; Miller 1974; Nocke and Peitz 2003; Rust 1986).

However, this paper illustrates that this belief is not always true; the retailer-operated used good market actually leads to higher manufacturer profits. There are two main reasons: 1) a retailer-operated used good market generates higher consumer valuations for new goods because of the consumers' ability to re-sell goods they no longer value as highly, to retailers who can re-sell them to consumers who most value the goods; and 2) the sale of used goods serves as a price discrimination mechanism, thereby expanding the total sales and increasing channel

[1] This information comes from personal interviews with textbook managers from college bookstores.

profit. Surprisingly, we prove that a clever manufacturer can gain from this process, and capture some of the extra value that is created by a used-good market run by its own retailer. This result holds even when a manufacturer cannot contract on the sale of used goods. The analysis thus suggests that the attractiveness of used-good marketing depends on the channel structure and demand structure for the used-good market in a fundamental way.

The paper is organized as follows. In Section 1, we describe the model. Section 2 studies the decisions of an integrated channel as a benchmark case, and the contracts that can induce these first-best decisions in a non-integrated vertical channel. In Section 3 we compare these results to the equilibrium when used goods cannot be sold, and show the conditions under which used-good sales improve manufacturer profitability. We conclude with a discussion of the results and suggestions for future research.

1 The model

We focus on a two-period model in which a firm markets a durable product through one intermediary. In the first period, only new durable goods are available. In the second period, consumers may have the option of buying either new or used goods. The players are rational and have full information. During the purchase decision, consumers are aware of the future value of the good and form rational expectations about the price at which they may sell their goods as used. Section 1.1 lays out the basic assumptions about the players in the model: the manufacturer, the retailer, and the consumers. Given these assumptions, the supply and demand equations for new and used goods are presented in Section 1.2.

1.1 Players

1.1.1 Manufacturer

As in Desai et al. (2004) and Jeuland and Shugan (1983), the manufacturing level is modeled as a monopoly facing a constant marginal cost of production, c. The manufacturer relies on an independent retailer to access consumers. Therefore, the manufacturer's objective is to maximize profit by choosing the optimal contract to offer the retailer. While the manufacturer commits to a price path, the parameters of the contract may change from the first period to the second period.[2]

1.1.2 Retailer

Consumers purchase the durable good from the retailer. The retailer purchases new units of the product from the manufacturer in the first period at a constant per unit wholesale price, w_1. The retailer chooses the quantity of new goods to purchase, based on the wholesale price. In the second period, the retailer faces a wholesale

[2] In the textbook industry, for example, the periods are easily defined by academic term.

price of w_2 and must choose both new and used quantities to sell. If the contract offered by the manufacturer is unsatisfactory, the retailer can choose to buy zero units of new product from the manufacturer, and sell only used goods, in the second period. First-period buyers who wish to sell their goods to the retailer for resale as used goods are paid c_u per unit by the retailer, which is the retailer's cost per unit for these used goods. The value of c_u is governed by the supply function for used goods, developed in the following section.[3] The retailer does not offer a market for new or used goods following the second period.

1.1.3 Consumers

Consumers are heterogeneous. As in previous research (Moorthy 1984; Purohit 1997), consumers' product valuations in the first period are denoted by the parameter ϕ_1, which is uniformly distributed between 0 and 1. Each consumer buys at most one unit of the product which provides utility for two periods. Consumers in the first period have a gross valuation of the product of $V(\phi_1)$, where

$V(\phi_1)=\phi_1$ if a new product is owned only in the first period
$V(\phi_1)=(1+\alpha)\phi_1$ if a product is owned in the first period and kept subsequently.

The product provides immediate utility of ϕ_1 in period 1; if it is kept in period 2, it generates further utility of $\alpha\phi_1$, where $\alpha<1$ to reflect depreciation in the good's value from the first to second periods. In the case of textbooks, for example, students may derive less value from keeping their introductory psychology textbook for later reference than from using the book in conjunction with the course. The choice for first period consumers is therefore whether to buy a new good in the first period, delay purchase until the second period or abstain from purchase entirely.

Note that the model allows for the possibility that a consumer in the market for the good in the first period abstains from purchase. For a range of prices, such consumers exist and are depicted in our model as populating the period-1 market, but as *non-buyers*. One might question whether this is a sensible outcome in a market like textbooks, where students taking a course are supposedly required to purchase the book. We therefore surveyed students in the author's upper-level MBA course to check for the presence of non-buyers in the population of current students. Our survey found that 52% of the students did not buy the *required* text for this course.[4] Sadly, real-world students who do not buy the textbook in the period in which they take the course do not buy the book later either, nor do they delay taking the course until later in order to buy the book later; the book purchase is not the driver for the decision to take a course. Consumers take the action that maximizes their utility.

[3] Previous literature (e.g. Desai et al. 2004) assumes a perfectly competitive secondary market in which consumers trade goods without the retailer. In such models, neither consumers nor the manufacturer profits from the trading of used goods. However, for markets like textbooks, the retailer will profitably sell both new and used goods, and we reflect this in our model.

[4] The text for this course was newly revised and therefore no used copies were available (as in our period 1). Interestingly, in other courses these students were taking concurrently, where used copies of required books were available (as in our period 2, described below in the text), students failed to buy 40% of their required books on average. Clearly, a non-buyer segment exists in both periods.

To maximize utility, a first period consumer will purchase in the first period if the net utility from buying the good is greater than the utility of not buying the good (which is normalized to zero). In calculating their net utility, consumers form a rational expectation of the buy-back price in the second period, $E(c_u)$. Thus, the utility of buying a new good in the first period is

$$\boldsymbol{u}_n(\phi_1) = \phi_1 - \boldsymbol{p}_{1n} + \mathbf{max}\{\boldsymbol{E}(\boldsymbol{c}_u), \alpha\phi_1\},$$

where $\alpha\phi_1$ is the value a consumer places on keeping the good after the first period and p_{1n} is the retail price of the good.[5] Note that we allow the first-period buyer to either keep the product for two periods (if, for example, the textbook could have some reference value to a student after the course is completed), or to re-sell the product to the used-good market at the end of the first period. The transaction and search costs of consumer-to-consumer trade are assumed to be sufficiently high to discourage consumers from selling to each other.[6]

In the second period, the market serves a new group of consumers whose valuations, ϕ_2, are uniformly distributed between 0 and γ.[7] In the case of textbooks, we expect that the distribution of consumer gross valuations would be the same for each period (academic term), meaning γ equals 1, although for the sake of generality, we allow γ to be less than or equal to 1. Second-period buyers' gross valuations of the goods are the same as for first period consumers, with the additional option of purchasing a used good:

$V(\phi_2) = (1 + \alpha)\phi_2$ if a new product is owned in the second period and subsequently

$V(\phi_2) = (\theta + \alpha)\phi_2$ if a used product is owned in the second period and subsequently,[8]

where $0<\alpha<\theta<1$.

[5] In this model it is assumed that the firms and the consumers have the same discount rate which is normalized to one without loss of generality. Analyzing the equilibrium outcome when consumers and firms have different discount rates is reserved for future research.

[6] While the emergence of the internet has decreased search costs, online dealers only represented 13.2% of total U.S. used book sales in 2003 (Siegel and Siegel 2004). The sentiments of two University of British Columbia students represent why consumer-to-consumer trading hasn't made a greater impact: "I've tried the bulletin board thing and ...the UBC Bookstore is a lot more convenient and I'm willing to pay the extra cost for that." "I wanted to get my books quickly, as classes were starting, and I didn't know anywhere else to go" (McRoberts 2004).

[7] As shown by Conlisk et al. (1984), examining a renewable population of consumers in period 2 obviates the need to deal with the well-known Coase conjecture (Tirole 2001), which shows that forward-looking consumers will rationally wait until price equals the firm's marginal cost of production unless the monopolist manufacturer can commit to a price. In a market like textbooks, the Coase problem does not exist, because (for example) the consumers who bought a marketing management textbook for fall semester are a different population from those taking the course in the spring semester.

[8] We assume that when the new good is used and retained, its value is the same as a used good that is retained. For example, in the textbook market, a new book has greater value than a used one for various reasons such as having no highlighting or notes written in it and having its spine and cover in perfect condition. However, once the book is used by the owner, it now has the owner's notes or highlighting in it and the cover becomes frayed. Now, it is in the same condition as the book that is purchased used. We show in the Technical Appendix that allowing for a used-used good to offer lower value to consumers than a used-new good does not have a qualitative impact on the results in this paper.

The parameter θ measures the depreciation in the utility value of the good from its new state (in period 1) to its used state (in period 2) as perceived by second-period consumers. Restricting attention to $\alpha<\theta$ reflects the time-dependency of demand. A first period consumer receives less value from period two ownership of the (now used) good than does a second period consumer. Such is the case for a textbook, whose value to the consumer who used it in last semester's class is less than the value to an entering consumer. The net utility of buying a new good in the second period at the retail price p_{2n} is given by

$$\boldsymbol{u}_n(\phi_2) = \phi_2 + \alpha\phi_2 - \boldsymbol{p}_{2n},$$

while the net utility of buying a used good at the retail price p_{2n} is given by

$$\boldsymbol{u}_u(\phi_2) = \theta\phi_2 + \alpha\phi_2 - \boldsymbol{p}_{2u}.$$

1.2 Used-good supply and consumer demand

In this subsection we derive the function for used good supply, as well as the inverse demand functions. These functions are valid when used goods are sold in the second period.

1.2.1 Supply of used goods

In deriving the inverse-supply function for used goods, we look at the first period consumer who is indifferent between keeping the good in period 2 and selling it at the buyback price, c_u. Let the location of this consumer be denoted ϕ_{1s}. For this consumer, $c_u=\alpha\phi_{1s}$. Of the consumers who purchased the good in the first period, those with valuations less than ϕ_{1s} will choose to sell their good as used. Let q_{tj} denote quantity for good-type j in period t. Therefore, the indifferent consumer is located at $\phi_{1s} = (1 - q_{1n} + q_{2u})$, as illustrated in Fig. 1. The inverse-supply function is then

$$\boldsymbol{c}_u = (\mathbf{1} - \boldsymbol{q}_{1n} + \boldsymbol{q}_{2u})\alpha. \tag{1}$$

In this model, lower valuation consumers decide to sell their good and opt out of the market. In previous models of secondary markets, the higher valuation consumers sell their goods in order to update and purchase a new good (Desai et al 2004; Hendel and Lizzeri 1999). In these models, the secondary market fuels new purchases by allowing high valuation consumers to discard old goods for money to be spent on subsequent new goods. While this assumption is reasonable for markets

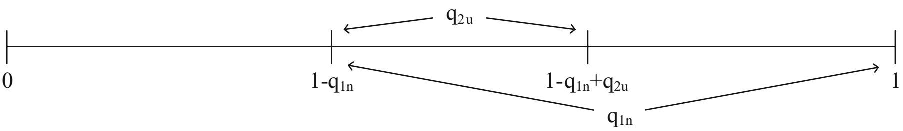

Fig. 1 Gross valuations held by indifferent consumers for first-period new good sales and used-good supply

like that for automobiles, our model is better suited for markets such as textbooks where the consumers who keep the good value it most.

1.2.2 First-period demand

The derivation of first-period demand is consistent with Purohit (1997). The retailer manages the market for both used and new goods. In determining the inverse-demand functions for new goods in period 1, we begin analysis with the marginal consumer who purchases a good (whose location we will denote as ϕ_{1n}). It is straightforward to show that there will not be a segment of first-period consumers who delay purchase until the second period if there are consumers who sell back their good as used.[9] Restricting our attention to situations where there is an active used-good market, the marginal consumer is indifferent between buying the new good (which generates utility of $\phi_1 - p_1 + \max\{E(c_u), \alpha\phi_1\}$) and abstaining from purchase (which generates zero utility). This marginal consumer is located at the value of ϕ_1 that solves $\phi_1 - p_1 + \max\{E(c_u), \alpha\phi_1\} = 0$. All consumers with valuations $\phi \in [\phi_1, 1]$ experience positive utility from purchasing a new good in the first period and consequently do purchase the good. Therefore, the indifferent consumer is located at the point where $\phi_{1n} = 1 - q_{1n}$. From Eq. 1, we can see that for this consumer, $c_u \geq \alpha\phi_{1n}$. The consumers' expectation of the buyback price $E(c_u)$ is formed by Eq. 1 with the expected used good quantity, $E(q_{2u})$ substituted in for q_{2u}. The market-clearing price is then

$$\begin{aligned} \boldsymbol{p}_{1n} &= (\mathbf{1} - \boldsymbol{q}_{1n}) + \boldsymbol{E}(\boldsymbol{c}_u) \\ &= (\mathbf{1} + \alpha)(\mathbf{1} - \boldsymbol{q}_{1n}) + \alpha \boldsymbol{E}(\boldsymbol{q}_{2u}). \end{aligned} \tag{2}$$

1.2.3 Second-period demand

In determining the inverse-demand functions for new and used goods in period 2, analysis begins with the marginal consumer who purchases a used good. We denote the valuation of the consumer who is indifferent between buying a new good and buying a used good as ϕ_{2n}. We denote the valuation of the consumer who is indifferent between buying a used good and abstaining from purchase as ϕ_{2u}. All second-period consumers with valuations $\phi \geq \phi_{2n}$ purchase a new good. All second-period consumers with valuations $\phi \in [\phi_{2u}, \phi_{2n}]$ purchase a used good. Thus, as illustrated in Fig. 2, $\phi_{2n} = (\gamma - q_{2n})$ and $\phi_{2u} = (\gamma - q_{2n} - q_{2u})$. Second period consumers recognize that there is no operated market for goods, new or used, in the

[9] To see that there cannot be a segment of first-period consumers who delay purchase until the second period if there are consumers who sell back their good as used, note that a consumer can gain positive utility from waiting and buying a used good in the second period only if $\alpha\phi_1 \geq p_{2u} \geq c_u \geq \alpha\phi_{1s}$. However, if there are consumers who sell back their good as used, then the consumer located at ϕ_{1s} buys a good in the first period implying that all consumers with $\alpha\phi_1 \geq \alpha\phi_{1s}$ will prefer to buy new in the first period rather than wait to buy used (as evident by simple comparison of utilities). Therefore, if some consumers sell their book back to the retailer, there will not be any consumer who gets greater utility from delaying purchase than buying in the first period.

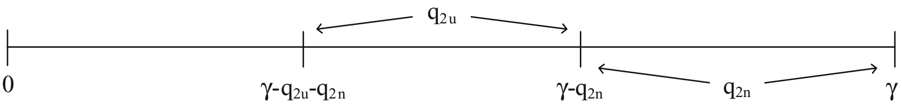

Fig. 2 Gross valuations held by indifferent consumers for second-period new and used-good sales

following period, implying that purchase cannot be delayed and the good will provide the terminal value $\alpha\phi_2$ after the second period. For the consumer indifferent between buying a used good and abstaining from purchase, the net utility from buying a used good is thus equal to zero. Therefore, $\theta\phi_{2u} + \alpha\phi_{2u} - \boldsymbol{p}_{2u} = \mathbf{0}$ and the market-clearing price is

$$\boldsymbol{p}_{2u} = (\gamma - \boldsymbol{q}_{2n} - \boldsymbol{q}_{2u})(\alpha + \theta). \tag{3}$$

To determine the inverse demand function for new goods in the second period, we look at the marginal consumer who purchases a new good. This consumer is indifferent between buying a new good and buying a used good. Hence, $\phi_{2n} + \alpha\phi_{2n} - \boldsymbol{p}_{2n} = \theta\phi_{2n} + \alpha\phi_{2n} - \boldsymbol{p}_{2u}$ and the market-clearing price is

$$\begin{aligned} p_{2n} &= (\gamma - \boldsymbol{q}_{2n})(\mathbf{1} - \theta) + \boldsymbol{p}_{2u} \qquad (4) \\ &= \gamma - \boldsymbol{q}_{2n} - \theta \boldsymbol{q}_{2u}. \end{aligned}$$

In the following section, we derive the first-best strategy for a channel facing demands as described above. We then identify a set of contracts offered to an independent retailer by which a manufacturer may induce this optimal strategy.

2 Coordinating the channel

In this section, we derive the quantity choices of a vertically-integrated channel that can make credible commitments to consumers in the initial period about first- and second-period quantities. While it is generally too costly or logistically difficult to engage in committed contracts with each consumer, this is the most profitable outcome and serves as a goal for the firm. We identify how and when this channel-profit maximizing outcome can be achieved in the absence of vertical integration and commitments to consumers. We show the contract that will induce the same actions as a vertically-integrated firm that can commit to quantities. We establish conditions defining when the manufacturer optimally ceases new-good sales in the second period and cedes the market to used goods.

2.1 The integrated channel with commitments to consumers

Channel profit is maximized if the firm integrates forward and can commit to first and second period quantities at once. In this ideal scenario, the manufacturer solves the following problem:

$$\max_{q_{1n}, q_{2n}, q_{2u}} \pi_{channel} = (\boldsymbol{p}_{2u} - \boldsymbol{c}_u)\boldsymbol{q}_{2u} + (\boldsymbol{p}_{2n} - \boldsymbol{c})\boldsymbol{q}_{2n} + (\boldsymbol{p}_{1n} - \boldsymbol{c})\boldsymbol{q}_{1n}$$
$$\boldsymbol{s.t.}\{\boldsymbol{q}_{2u}, \boldsymbol{q}_{1n}, \boldsymbol{q}_{2n}\} \geq \mathbf{0}.$$

Table 1 reports optimal quantities under channel integration, assuming that $\frac{\alpha}{\alpha+\theta} < \gamma < \frac{2\alpha+\theta}{(2-\theta)(\alpha+\theta)}$ (which ensures that used-good margins are positive and that some consumers decide to keep their good as used if $q_{2n}>0$). There are critical values of the marginal cost of product c, that define three regions of interest.[10] First, for low marginal cost (specifically, $c<c^*(\gamma, \alpha, \theta)$), the firm will sell both new and used goods in the second period. When the firm faces an intermediate marginal cost of production $(c^*(\gamma,\alpha,\theta)<c<c^{**}(\gamma,\alpha,\theta))$, it will cease production of new goods in the second period, but some first-period buyers keep their product in the second period ($q_{1n}>q_{2u}$). Finally, with a high marginal cost of production ($c>c^{**}(\gamma, \alpha, \theta)$), the firm essentially operates a rental market in which all first period purchases are sold back to the firm and re-sold as used ($q_{1n}=q_{2u}$); in this region as well, the firm produces no new units in the second period.[11] In effect, if it is very costly to produce the good (if $c>c^*(\gamma, \alpha, \theta)$), the manufacturer can "economize" on producing new-good units by producing all of them in period 1, because some of the period-1 units can "create" sales in period 2 through the resale market, without necessitating the production of new units in period 2.[12]

Optimal prices can be directly calculated, as well as the optimal quantities presented here; however, we defer a discussion of profitability to Section 3 below, where the relative profitability of various decentralized-channel options can be compared both amongst themselves and to this integrated "first-best" scenario. With an understanding of the benchmark case of the coordinated channel, we now turn to a discussion of the equilibrium outcomes in a decentralized channel with an independent retailer.

2.2 Coordinating contracts in a decentralized channel

In this section, we modify the model to consider a Stackelberg-leading manufacturer selling its products through an independent retailer who has the ability to proactively buy products back from period 1 consumers and resell them profitably as used goods

[10] The critical values of c are defined as $c^*(\gamma,\alpha,\theta) \equiv \frac{\gamma(1+\alpha)\left(2\alpha-\alpha\theta+\theta-\theta^2\right)}{2\alpha+\theta}$ and $c^{**}(\gamma,\alpha,\theta) \equiv 1+\alpha-\gamma+\frac{\alpha}{\alpha+\theta}$.

[11] For $c > 1+\gamma(\alpha+\theta)$, which is greater than $c^{**}(\gamma, \alpha, \theta)$, the marginal cost of production prohibits the profitable selling of the good. In this case, the firm abstains from operating a market of any kind. We restrict our attention to values of c low enough so that production is in fact profitable.

[12] Note that both $c^*(\gamma, \alpha, \theta)$ and $c^{**}(\gamma, \alpha, \theta)$ are decreasing in θ (recalling that α<θ), and increasing in α. Then intuitively, as new and used goods become closer substitutes (i.e., as θ increases in value), this focusing of production in period 1 alone becomes more attractive (so that the c threshold drops). For new-good sales in the second period nevertheless to be positive, the marginal production cost of new goods must be low enough to compete with used goods in period 2. In contrast, a higher α value means that the period-2 value of the good to a period-1 buyer increases. This means that the retailer has to offer a higher buyback price (c_u) to induce period-1 buyers to supply units to the used-good market, which makes new-good production in period 2 relatively more attractive, even at higher marginal costs. Also notice that $c^*(\gamma, \alpha, \theta)$ increases with γ. The increase in consumer gross valuations and market size associated with γ makes it such that serving the higher valuation consumers with new goods is attractive to the firm, even at a higher marginal cost of production. Conversely, $c^{**}(\gamma, \alpha, \theta)$ decreases with γ because the greater market size increases the demand for used goods and thus creates a greater incentive to buy back all units sold as new in the initial period.

Table 1 Equilibrium quantities for integrated channel with commitments to consumers

	New and used in 2nd period $c < c^*(\gamma, \alpha, \theta)$	Only used in 2nd period $c^*(\gamma, \alpha, \theta) \le c < c^{**}(\gamma, \alpha, \theta)$	Only used in 2nd period $c \ge c^{**}(\gamma, \alpha, \theta)$
q^*_{1n}	$\frac{\theta(1-c-\theta+c\theta)+\alpha\left(2-2c+2\alpha+2c\theta-\theta^2-\alpha\theta\right)}{2(1+\alpha)\left(2\alpha+\theta-\alpha\theta-\theta^2\right)}$	$\frac{\theta(1-c+\alpha+\alpha\gamma)+\alpha(2-2c+\alpha+\alpha\gamma)}{2(\alpha^2+2\alpha+\theta+\alpha\theta)}$	$\frac{1-c+\gamma(\alpha+\theta)}{2(1+\alpha+\theta)}$
q^*_{2n}	$\frac{1}{2}\left[\gamma - \frac{c(2\alpha+\theta)}{(1+\alpha)\left(2\alpha+\theta-\alpha\theta-\theta^2\right)}\right]$	0	0
q^*_{2u}	$\frac{c\theta}{2\left(2\alpha+\theta-\alpha\theta-\theta^2\right)}$	$\frac{\gamma(1+\alpha)(\alpha+\theta)-c\alpha}{2(\alpha^2+2\alpha+\theta+\alpha\theta)}$	$\frac{1-c+\gamma(\alpha+\theta)}{2(1+\alpha+\theta)}$

$c^*(\gamma, \alpha, \theta) \equiv \frac{\gamma(1+\alpha)\left(2\alpha-\alpha\theta+\theta-\theta^2\right)}{2\alpha+\theta}$ and $c^{**}(\gamma, \alpha, \theta) \equiv 1+\alpha-\gamma+\frac{\alpha}{\alpha+\theta}$.

in period 2. Taking this extension into account does not preclude a coordinated-channel outcome, but achieving that coordinated outcome requires that the manufacturer use specific contracting options. In particular, when it is optimal for the channel to sell new and used goods in the second period, simple two-part contracts will not coordinate the channel to reach its maximum potential. In the second period, the manufacturer has three goals to accomplish: inducing the optimal used-good quantity, inducing the optimal new-good quantity, and sharing revenue. As exemplified by Mathewson and Winter (1984), the manufacturer can accomplish three goals using three contracting instruments. However, the manufacturer has no direct control over the retailer's choice of used goods and consequently cannot contract upon used-goods sales. Recognizing the interdependence of demand for new and used goods, the manufacturer may impose restrictions on the retail price of new goods in conjunction with a per-unit wholesale price in order to control the sales of used goods. This contracting over retail price can take the form of a price ceiling. To show how these contracting instruments can be used to coordinate the distribution channel for durable goods with an imperfect secondary market, we model a price ceiling, denoted by P_{2n}, which limits the maximum price the retailer may charge for new goods.[13] This channel-coordinating contract is different from the marginal-cost pricing contract suggested by Jeuland and Shugan (1983), or even second-period marginal cost pricing as in Desai et al. (2004). The retail price maintenance in this contract differs from the price floor proposed in Mathewson and Winter (1984) in that higher retail prices are penalized rather than encouraged.

Below, we develop the logic for this contract. The manufacturer is the Stackelberg leader, offering the retailer a take-it-or-leave-it contract. As in Desai et al. (2004), we assume that the manufacturer can make a credible commitment about second period contract terms at the beginning of period one. The manufacturer sets the terms of the contract over the two-period span and the retailer chooses first period quantity to sell at the market clearing price. Demand is realized and then the retailer chooses the quantity of used goods to purchase from consumers at the supply-function governed price and sell at the market-clearing price, along with new good quantity to sell at

[13] It is important to note that such a contract is not per se illegal (Felsenthal 1997). In the *State Oil Company v. Khan* case of 1997, the Supreme Court ruled that maximum resale price restraints are permitted (Blair and Lafontaine 1999). Resale price maintenance is acceptable if it is unilaterally applied to all downstream partners and if it is not anti-competitive (Coughlan et al. 2006; Nagle and Holden 2002).

the market-clearing price. The market-clearing prices are given by the inverse-demand functions of Eqs. 1–4. All channel members, including consumers, have rational expectations.

We use a sub-game perfect Nash equilibrium solution concept. In the second period, the retailer's objective depends on whether or not the retailer decides to sell new goods from the manufacturer. If no new goods are sold in the second period, the manufacturer's second period agreement does not apply. We examine each case. We first consider the case in which both new and used goods are sold in the second period. The retailer maximizes second-period profits, given by:

$$\begin{array}{l}\pi_2^{ret} = (\boldsymbol{p}_{2u} - \boldsymbol{c}_u)\boldsymbol{q}_{2u} + (\boldsymbol{p}_{2n} - \boldsymbol{w}_2)\boldsymbol{q}_{2n} - \boldsymbol{F}_2 \\ \boldsymbol{s.t.}\,\boldsymbol{p}_{2n} \le \boldsymbol{P}_{2n}\end{array} \tag{5}$$

where we allow for the manufacturer to charge the retailer a wholesale price, w_2, a fixed fee, F_2, and set a retail price ceiling, P_{2n}. The retailer chooses the optimal q_{2u} and q_{2n} to maximize profits, yielding best-response functions of the form $q_{2n}(q_{1n}, P_{2n}, w_2; \alpha, \theta, c, \gamma)$ and $q_{2u}(q_{1n}, P_{2n}, w_2; \alpha, \theta, c, \gamma)$.

It is important to note that in the second period, the retailer can sell used goods without purchasing any new goods at wholesale prices from the manufacturer. In order to induce the retailer to sell both new and used goods in period 2, the manufacturer must leave the retailer with at least the profits the retailer can earn from monopolistically selling only used goods. Given q_{1n}, this value is the result of maximizing the profit function: $\Gamma = (\boldsymbol{p}_{2u} - \boldsymbol{c}_u)\boldsymbol{q}_{2u}$.

Given a first period quantity, the maximum value this can take is:[14]

$$\Gamma^*(\boldsymbol{q}_{1n}) = \frac{(\gamma\theta - \alpha + \alpha q_{1n} + \alpha\gamma)^2}{4(2\alpha + \theta)}. \tag{6}$$

The retailer's option to sell only used goods puts a constraint on the fixed fee the manufacturer can charge:

$$F_2 \le (p_{2u} - c_u)q_{2u} + (p_{2n} - w_2)q_{2n} - \Gamma^*(q_{1n}). \tag{7}$$

Because manufacturer profit in the second period, $\pi_2^{mfgr} = F_2 + (w_2 - c)q_{2n}$, is strictly increasing in F_2, the constraint in Eq. 7 will bind in equilibrium. Meanwhile, in the first period, the retailer knows that the second period profits, $(p_{2u} - c_u)q_{2u} + (p_{2n} - w_2)q_{2n} - F_2$, will be reduced to $\Gamma^*(q_{1n})$. The retailer's choice of new goods to order in the first period will be a rational expectations equilibrium if it solves:

$$\begin{array}{l}\max\limits_{q_{1n}} \pi_{1\,and\,2}^{ret} = (p_{1n} - w_1)q_{1n} - F_1 + \Gamma^*(q_{1n}) \\ s.t.\,E(q_{2u}) = q_{2u}(q_{1n}, P_{2n}, w_2; \alpha, \theta, c, \gamma)\end{array}. \tag{8}$$

The retailer will accept the first period contract if, in equilibrium, the retailer's total profit is greater than or equal to the minimum acceptable pay-off, $\underline{\pi}^{ret}$. Therefore the manufacturer must charge a fixed fee such that

[14] Proof of this statement is in the Technical Appendix.

$F_1 \leq (p_{1n} - w_1)q_{1n} + (p_{2n} - w_2)q_{2n} + (p_{2u} - c_u)q_{2u} - F_2 - \underline{\pi}^{ret}$. The manufacturer chooses F_1, F_2, w_1, w_2, and P_{2n} to maximize total profit below:

$$\begin{aligned} \pi^{mfgr} &= F_1 + (w_1 - c)q_{1n} + F_2 + (w_2 - c)q_{2n} \\ s.t. \quad & F_1 \leq (p_{1n} - w_1)q_{1n} + (p_{2n} - w_2)q_{2n} + (p_{2u} - c_u)q_{2u} - F_2 - \underline{\pi}^{ret} \\ & F_2 \leq (p_{2u} - c_u)q_{2u} + (p_{2n} - w_2)q_{2n} - \Gamma^* \\ & q_{2n}(P_{2n}, w_1, w_2; \alpha, \theta, c, \gamma) \geq 0. \end{aligned} \tag{9}$$

With profits strictly increasing in F_1 and F_2, the constraints will bind. Substituting in the constrained values of F_1 and F_2, the manufacturer chooses w_1, w_2 and P_{2n} to maximize: $\pi^{\text{mfgr}} = (\boldsymbol{p}_{2u} - \boldsymbol{c}_u)\boldsymbol{q}_{2u} + (\boldsymbol{p}_{2n} - \boldsymbol{c})\boldsymbol{q}_{2n} + (\boldsymbol{p}_{1n} - \boldsymbol{c})\boldsymbol{q}_{1n} - \underline{\pi}^{ret}$, where p_{tj} and c_{u} are given by Eqs. 1–4 and the quantities are given by the best-response functions from the retailer's optimization problem.

Derived from the Kuhn-Tucker conditions, the equilibrium contract for the manufacturer to offer the retailer if $\boldsymbol{c} < \boldsymbol{c}^*(\alpha, \theta) \equiv \frac{\gamma(\mathbf{1}+\alpha)(\mathbf{2}\alpha - \alpha\theta + \theta - \theta^2)}{\mathbf{2}\alpha + \theta}$ is defined in Proposition 1:

Proposition 1 *For c<c*(γ, α, θ) the following multi-part tariff coordinates the distribution channel:*

$$\boldsymbol{w}_1^* = \frac{\mathbf{1}}{\mathbf{4}}\left[\mathbf{4}\boldsymbol{c} + \mathbf{2}\alpha\gamma - \frac{\alpha^2(\mathbf{1} + \mathbf{2}\gamma)}{\mathbf{2}\alpha + \theta} - \frac{\boldsymbol{c}\alpha(\alpha + \theta)}{(\mathbf{1} + \alpha)(\mathbf{2}\alpha + \theta - \alpha\theta - \theta^2)} + \frac{\alpha(\alpha - \boldsymbol{c}\alpha + \alpha^2 - \boldsymbol{c}\theta)}{\alpha^2 + \mathbf{2}\alpha + \theta - \alpha\theta - \theta^2}\right]$$

$$\boldsymbol{w}_2^* = \boldsymbol{c} + \frac{\alpha(\mathbf{1} + \alpha)(\mathbf{1} - \boldsymbol{c})}{\mathbf{2}(\alpha + \theta)} + \frac{\boldsymbol{c}\alpha^2(\mathbf{2} - \theta)}{\mathbf{2}(\mathbf{2}\alpha + \theta - \alpha\theta - \theta^2)}$$

$$\boldsymbol{P}_{2n}^* = \frac{\gamma + \alpha\gamma + \boldsymbol{c}}{\mathbf{2}}$$

$$\boldsymbol{F}_1^* = (\boldsymbol{p}_{1n}^* - \boldsymbol{w}_1^*)\boldsymbol{q}_{1n}^* + (\boldsymbol{p}_{2n}^* - \boldsymbol{w}_2^*)\boldsymbol{q}_{2n}^* + (\boldsymbol{p}_{2u}^* - \boldsymbol{c}_u^*)\boldsymbol{q}_{2u}^* - \boldsymbol{F}_2^* - \underline{\pi}^{ret}$$

$$\boldsymbol{F}_2^* = (\boldsymbol{p}_{2n}^* - \boldsymbol{w}_2^*)\boldsymbol{q}_{2n}^* + (\boldsymbol{p}_{2u}^* - \boldsymbol{c}_u^*)\boldsymbol{q}_{2u}^* - \Gamma^*.$$

This tariff replicates the outcomes of a vertically-integrated firm that can make credible quantity commitments to consumers. In this contract, the manufacturer charges $w_1^* > c$ *and a fixed fee* F_1^* *in the first period. In the second period, the manufacturer charges* $w_2^* > c$ *and a fixed fee,* F_2^**, in addition to imposing a maximum resale price,* P_{2n}^**. The retailer makes only a normal return to its capital, while the manufacturer garners the remainder of total channel profits.*

The optimal contract in Proposition 1 has several notable features, and differs from that derived in Desai et al. (2004). While previous researchers have found marginal-cost pricing or above-cost pricing necessary to coordinate the channel (Desai et al. 2004; Jeuland and Shugan 1983), Proposition 1 shows that other contracting instruments are also required.

A notable feature of the contract in Proposition 1 is the fact that F_2^*, the fixed fee in the second period,[15] can be negative in portions of the parameter space. This implies that the manufacturer offers the retailer a fixed incentive to carry new goods,

[15] The fixed fee is presented in its entirety in the Technical Appendix.

similar to a slotting fee. While there typically are no fixed fees in the textbook market, the publisher often negotiates deals on the shipping costs of an order.[16] Offering free shipping serves the same role as the negative fixed fee in our model and charging above cost shipping rates serves as a positive fixed fee transfer.

Finally, the optimal contract in Proposition 1 imposes a maximum resale price for new goods in period 2, P^*_{2n}. This is necessary to control the retailer's incentive to raise the price of new goods in period 2, given the ability to profitably sell used goods as well.[17]

Proposition 1 characterizes the optimal contract and its implications for sales and profitability for low values of marginal production cost (c), leading to sales of both new and used goods in period 2. What then is the optimal contract for higher production costs, leading to an equilibrium with no new-good sales in period 2? If the contract offered to the retailer leads it to choose to sell only used goods in the second period, the retailer's problem becomes:

$$\begin{array}{c} \max\limits_{q_{2u}} \pi_2^{ret}(\boldsymbol{p}_{2u}-\boldsymbol{c}_u)\boldsymbol{q}_{2u} \\ \boldsymbol{s.t.}\ \boldsymbol{q}_{2u} \leq \boldsymbol{q}_{1n} \end{array}. \tag{10}$$

The retailer's second period profits are maximized according to the expressions below:

$$\begin{array}{l} \boldsymbol{q}_{2u}(\boldsymbol{q}_{1n};\gamma,\alpha,\theta) = \frac{\alpha(-\mathbf{1}+\boldsymbol{q}_{1n}+\gamma)+\gamma\theta}{2(2\alpha+\theta)}\ \textbf{if}\ \boldsymbol{q}_{1n} \geq \frac{-\alpha+\gamma(\alpha+\theta)}{\mathbf{3}\alpha+\mathbf{2}\theta} \\ \boldsymbol{q}_{2u}(\boldsymbol{q}_{1n};\gamma,\alpha,\theta) = \boldsymbol{q}_{1n}\ \textbf{if}\ \boldsymbol{q}_{1n} < \frac{-\alpha+\gamma(\alpha+\theta)}{\mathbf{3}\alpha+\mathbf{2}\theta} \end{array} \tag{11}$$

In a rational expectations equilibrium, the consumers' expectations on q_{2u} must be accurate. The retailer's first period problem is to choose q_{1n} in order to

$$\begin{array}{l} \max\limits_{q_{1n}}(\boldsymbol{p}_{1n}-\boldsymbol{w}_1)\boldsymbol{q}_{1n}+(\boldsymbol{p}_{2u}-\boldsymbol{c}_u)\boldsymbol{q}_{2u}-\boldsymbol{F}_1 \\ \qquad \boldsymbol{s.t.}\quad \boldsymbol{q}_{2u}(\boldsymbol{q}_{1n};\gamma,\alpha,\theta) = \boldsymbol{E}(\boldsymbol{q}_{2u}) \equiv \boldsymbol{I}^*\left(\textbf{arg}\ \max\limits_{q_{2u}}\pi_2^{ret}\right) + (\mathbf{1}-\boldsymbol{I})\boldsymbol{q}_{1n} \end{array} \tag{12}$$

where I is an indicator variable taking the value 1 if $\boldsymbol{q}_{1n} \geq \frac{-\alpha+\gamma(\alpha+\theta)}{3\alpha+2\theta}$ and 0 otherwise. Via backward induction, we solve for the sub-game perfect equilibrium contract offered by the manufacturer when the retailer sells only used goods in the second period (that is, when $c>c^*(\gamma,\ \alpha,\ \theta)$):

$$\begin{array}{l} \boldsymbol{w}_1^* = \boldsymbol{c} \\ \boldsymbol{w}_2^*\ \textbf{is not applicable} \\ \boldsymbol{P}_{2n}^*\ \textbf{is not applicable} \\ \boldsymbol{F}_1^* = \left(\boldsymbol{p}_{1n}^* - \boldsymbol{w}_1^*\right)\boldsymbol{q}_{1n}^* + \left(\boldsymbol{p}_{2u}^* - \boldsymbol{c}_u^*\right)\boldsymbol{q}_{2u}^* - \underline{\pi}^{\text{ret}} \\ \boldsymbol{F}_2^*\ \textbf{is not applicable}, \end{array} \tag{13}$$

where q^*_{tj} are the equilibrium quantities defined in Table 2.

[16] This practice was discussed in personal interviews with textbook managers from college bookstores.

[17] One may argue that the commitment by the manufacturer is legally binding, but that the retailer and manufacturer may choose to renegotiate after the first period if there is the potential to increase the profits of each. However, we know from existing literature on repeated games that the future value of continuing a relationship can prevent opportunistic behavior (Friedman 1971; Radner 1981). Potential gains from renegotiating and ignoring first-period consumer expectations can be eliminated by the loss in profit due to re-formed second-period consumer expectations. We show this in the Technical Appendix.

Table 2 Equilibrium quantities for decentralized channel when no new goods are sold in second period

	$c^*(\gamma, \alpha, \theta) \le c < \overline{c}(\gamma, \alpha, \theta)$	$\overline{c}(\gamma, \alpha, \theta) \le c < \widetilde{c}(\gamma, \alpha, \theta)$	$\widetilde{c}(\gamma, \alpha, \theta) \le c < 1 + \gamma(\alpha + \theta)$
q_{1n}^*	$\frac{2(\alpha+\theta)(1-c+\alpha+\alpha\gamma)+2\alpha(1-c)}{\alpha(8+5\alpha)+4\theta(1+\alpha)}$	$\frac{-\alpha+\gamma(\alpha+\theta)}{3\alpha+2\theta}$	$\frac{1-c+\gamma(\alpha+\theta)}{2(1+\alpha+\theta)}$
q_{2n}^*	0	0	0
q_{2u}^*	$\frac{1}{6}\left[3\gamma - \frac{\alpha(1+\gamma)}{2\alpha+\theta} - \frac{2\alpha(1+3c+\alpha+\gamma(4+\alpha))}{\alpha(8+5\alpha)+4\theta(1+\alpha)}\right]$	$\frac{-\alpha+\gamma(\alpha+\theta)}{3\alpha+2\theta}$	$\frac{1-c+\gamma(\alpha+\theta)}{2(1+\alpha+\theta)}$

$\overline{c}(\gamma, \alpha, \theta) \equiv 1 + \alpha - \gamma + \frac{\alpha(1+\gamma)}{2(2\alpha+\theta)} + \frac{(2-\alpha)(2+\gamma)}{6\alpha+4\theta}$ and $\widetilde{c}(\gamma, \alpha, \theta) \equiv \frac{\alpha(5-2\gamma+2\alpha+\alpha\gamma)+\theta(2-2\gamma+2\alpha+\alpha\gamma)}{3\alpha+2\theta}$. For $c < \overline{c}$, some first-period buyers keep their goods in the second period, while for $c \ge \overline{c}$, all first-period buyers sell back their goods for resale in the secondary market.

Comparing the equilibrium quantities in Table 2 to the entries in Table 1, we see that the decentralized channel cannot always mimic a vertically integrated channel that can make credible consumer commitments. Proposition 2 follows from Eq. 13, analysis of the entries in Table 2, and comparison of these to the entries in Table 1.

Proposition 2 *For $c > c^*(\gamma, \alpha, \theta)$ in equilibrium, the manufacturer charges w_1^* equal to the marginal cost of production, c, and a fixed fee F_1 in the first period, and ceases production in the second period, in which the retailer sells only used goods. If no first-period consumers keep their purchase in the second period, that is, $c \ge \widetilde{c}(\gamma, \alpha, \theta) \ge c^*(\gamma, \alpha, \theta)$, then the maximum profits of an integrated channel are achieved. If any first-period consumers keep their purchase in the second period, the equilibrium outcome nets the channel lower profits than if credible commitments to consumers were feasible.*

Proposition 2 defines the condition for the manufacturer to halt production in the second period and willingly cede the market to used goods. Desai et al. (2004) do not consider the possibility of halting new-good sales in the second period. Bulow (1982) finds that production of new goods will be halted when the number of potential consumers is fixed in the first period and either the industry is competitive or the monopolist producer rents the product to consumers. Proposition 2 shows the conditions under which ceasing new-good sales in period 2 is optimal and it highlights a new strategic incentive for limiting new goods production to the first period as compared to the motivation in Bulow (1982), even when additional consumers join the market in a later period. Specifically, for high marginal production costs of new goods, used goods serve as a lower cost source of channel profit, a portion of which the manufacturer is able to capture because of the profitable operation of the used-good market through the retailer.

Note that Proposition 2 also shows a loss in channel profitability with no new goods sold in period 2 as compared to the situation with positive second-period new-good sales. This profit loss occurs because the manufacturer's commitment to the retailer for the second period is irrelevant when there are no new goods sold in this period (when $c > c^*(\gamma, \alpha, \theta)$). The manufacturer loses a level of influence over second period quantities, thereby altering the equilibrium quantities and reducing channel profit. The manufacturer can only regain control of the secondary market when the quantity of used goods available is bound by the supply (new goods sold in the first period as a reaction to the manufacturer's wholesale price). Desai et al.

Table 3 Equilibrium quantities for decentralized channel without a secondary market

	New goods in 2nd period: $c < (1+\alpha)\gamma$	No new goods in 2nd period: $c \geq (1+\alpha)\gamma$
q^*_{1n}	$\frac{1-c+\alpha}{2(1+\alpha)}$	$\frac{1-c+\alpha}{2(1+\alpha)}$
q^*_{2n}	$\frac{1}{2}\left(\gamma - \frac{c}{1+\alpha}\right)$	0

(2004) find that selling through a retailer allows the manufacturer of durable goods to achieve first-best profits of renting. However, when the retailer operates a profitable secondary market (rather than a frictionless secondary market operated by consumers), Proposition 2 highlights conditions under which the first-best channel profits are unattainable.

With this understanding of the role of the imperfect secondary market, we turn in the following section to an examination of the effect of eliminating the secondary market.

3 Shutting down the secondary market

In this section, we investigate whether a manufacturer would choose to shut down the used-goods market. There are methods by which manufacturers have the ability to make used goods obsolete; for example, in the textbook industry, publishers may issue a new edition. We examine the optimal quantities and equilibrium profits of the manufacturer when used goods cannot be traded in order to determine if the secondary market is, in fact, detrimental to the manufacturer. The equilibrium when no secondary market exists is derived in the Technical Appendix and described in Table 3 below.

To determine if the manufacturer should wish to eliminate the secondary market, we compare the profits earned by the manufacturer when there is a secondary market to the profit earned when there is not a secondary market. The manufacturer profits are presented in Table 4, and lead directly to Proposition 3:

Proposition 3 *When the equilibrium solution involves sales of both new and used goods in the second period, the manufacturer and the channel earn greater profits when the retailer operates a profitable secondary market than when there is no secondary market.*

From this result, we see that the manufacturer may not choose to terminate the used market, even if doing required no additional investment. Proposition 3 differentiates our findings from those in the prior research literature, which found that the incentive to kill off the secondary market is increasing in the substitutability between new and used goods (Liebowitz 1982; Miller 1974; Rust 1986). While Desai et al. (2004) do not examine this possibility, previous research has shown the secondary market may increase manufacturer profit when the selling of used goods frees consumers to make an additional purchase of a new good (Ghose et al. 2005; Hendel and Lizzeri 1999). Our model proves it is not necessary for consumers to purchase multiple goods in order for the secondary market to have a positive impact on profits.

Table 4 Manufacturer profits

Vertical integration:	
$c < c^*(\gamma, \alpha, \theta)$	$\frac{(1+\alpha)^2(1+\gamma^2)-2c(1+\alpha)(1+\gamma)}{4(1+\alpha)} + \frac{c^2(2-\theta)(2\alpha+\theta)}{4(1+\alpha)(2\alpha+\theta-\alpha\theta-\theta^2)}$
$c^*(\gamma, \alpha, \theta) \leq c < c^{**}(\gamma, \alpha, \theta)$	$\frac{\alpha[2c^2-2c(2+\alpha+\alpha\gamma)+(1+\alpha)(2+\alpha+\alpha\gamma^2)]}{4(\alpha^2+2\alpha+\theta+\alpha\theta)} + \frac{\theta[(1-c+\alpha)^2-2c\alpha\gamma+2\alpha(1+\alpha)\gamma^2]+(1+\alpha)\gamma^2\theta^2}{4(\alpha^2+2\alpha+\theta+\alpha\theta)}$
$c > c^{**}(\gamma, \alpha, \theta)$	$\frac{(1-c+\alpha\gamma+\gamma\theta)^2}{4(1+\alpha+\theta)}$
Decentralized channel:	
$c < c^*(\gamma, \alpha, \theta)$	$\frac{(1+\alpha)^2(1+\gamma^2)-2c(1+\alpha)(1+\gamma)}{4(1+\alpha)} + \frac{c^2(2-\theta)(2\alpha+\theta)}{4(1+\alpha)(2\alpha+\theta-\alpha\theta-\theta^2)} - \underline{\pi}^{ret}$
$c^*(\gamma,\alpha,\theta) \leq c < \bar{c}(\gamma,\alpha,\theta)$	$\frac{[\alpha(-1+\gamma)+\gamma\theta]^2}{4(2\alpha+\theta)} + \frac{[\alpha(2-2c+\alpha+\alpha\gamma)+\theta(1-c+\alpha+\alpha\gamma)]^2}{(2\alpha+\theta)[4\theta(1+\alpha)+8\alpha+5\alpha^2]} - \underline{\pi}^{ret}$
$\bar{c}(\gamma,\alpha,\theta) \leq c < \tilde{c}(\gamma,\alpha,\theta)$	$\frac{(\gamma\alpha-\alpha+\theta\gamma)(\alpha(4-3c+\alpha-\gamma+2\alpha\gamma)+\theta(2-2c+\alpha-\gamma+3\alpha\gamma)+\gamma\theta^2}{(3\alpha+2\theta)^2} - \underline{\pi}^{ret}$
$\tilde{c}(\gamma, \alpha, \theta) \leq c < 1+\gamma(\alpha+\theta)$	$\frac{(1-c+\alpha\gamma+\theta\gamma)^2}{4(1+\alpha+\theta)} - \underline{\pi}^{ret}$
Decentralized channel without secondary market:	
$c < (1+\alpha)\gamma$	$\frac{2c^2-2c(1+\alpha)(1+\gamma)+(1+\alpha)^2(1+\gamma)^2}{4(1+\alpha)} - \underline{\pi}^{ret}$
$c \geq (1+\alpha)\gamma$	$\frac{(1-c+\alpha)^2}{4(1+\alpha)} - \underline{\pi}^{\mathrm{ret}}$

To help explain how manufacturer profits are increased when the retailer operates a secondary market, we examine how the total quantity of goods sold is different with and without a secondary market. We summarize the finding in Proposition 4.[18]

Proposition 4 *When the equilibrium solution involves sales of both new and used goods in the second period, the existence of a secondary market expands the number of consumers who ever buy the product. Specifically, sales of new goods in period* 1 *unambiguously increase with the existence of a secondary market; sales of new goods in period* 2 *decrease; and total new-good sales across the two periods may increase or decrease with a secondary market. If total new-good sales across the two periods decrease with a secondary market, incremental unit sales of used goods in period* 2 *more than compensate for the loss in new-good unit sales.*

From Proposition 4, we see that the secondary market serves to expand the total volume of sales to consumers, *and* to expand unit sales of new goods in the first period. Used goods serve as a price discrimination mechanism, offering the channel an additional product to capture low-valuation consumers in the second period.

In addition to serving as a price discrimination mechanism, the secondary market serves to add value to first-period consumers. Purchasing the good in the first period gives consumers their one-period valuation of the good as well as the opportunity to profit from selling the good back to the retailer. The buy-back price that induces consumers to sell back is by definition greater than or equal to the marginal first-period buyer's value of the good. Therefore, the existence of an imperfect secondary market increases the willingness to pay of lower valuation consumers and thus the profitability of the channel. Second-period new-good unit sales suffer as a result

[18] We thank a reviewer for suggesting this avenue of analysis to us.

(relative to the situation with no secondary market), but the added product-line depth offered by used goods increases total sales.

4 Discussion

This paper has shown that a durable goods manufacturer can obtain maximum profit in contracting with a retailer who is also selling used goods. When the coordinated channel would choose to sell both new and used goods, we show that the optimal contract under channel decentralization is different from the coordinating contract employed by Desai et al. (2004) for durable goods. The optimal contract must specify guidelines for retail price, and must also include a fixed fee and a wholesale price different from marginal cost. In contrast, when it is not optimal to offer new goods for sale in period 2, we show that there are cases for which the optimal contract is the same two-part tariff with marginal cost pricing as in Jeuland and Shugan (1983). However, there are conditions under which this optimal contract does not induce the first-best channel outcome of a firm that can rent to consumers.

Our results are driven by the relaxation of the assumption of a perfectly competitive marketplace for used goods. This is a realistic modification: in reality, search costs or auction costs prohibit the free transfer of goods to those who value them most. In many cases, such as the textbook market, a retailer does earn a profit from selling used goods. Allowing the retailer to profit from buying and selling used goods impacts the retailer's pricing incentives. To coordinate the channel, the manufacturer must design a contract to align these incentives with those of an integrated channel. The profitable used-good market expands the number of consumers who purchase a good and serves as a mechanism for price discrimination. It provides the retailer with an option to reach consumers who have a lower valuation for the product. This price discrimination allows the channel to earn greater profits. The manufacturer can capture these profits in the first period, because the retailer cannot have the option to sell used goods if new goods have never been sold. The secondary market also increases the number of new goods sold at a given retail price. Without a secondary market, the marginal consumer can expect to earn in the second period only the utility of maintaining possession of the good. The secondary market allows this consumer to earn a buyback price that is greater than the utility earned from keeping the good. Thus, for a given first-period retail price, more consumers will buy the good due to the increase in utility.

This result is in contrast to prior research by Bulow (1982) and Waldman (1996) who find that durability damages a monopolist's profits. In their research, all consumers are present in the market in the first period. Further, all consumers who purchase a good are ready to do so in the first period. Additionally, they do not allow for the retailer to profitably trade used goods. Our model allows for the fact that there are consumers whose value for the good is time-dependent. This matches certain markets particularly well, for example the textbook industry. In the textbook market, there is a new group of students who take a particular course each term. As our survey of MBA students shows, even among a group of students enrolled in a course, not everyone buys the textbook. After completion of the course, they are no longer in the market to buy a new copy of the same textbook next term, but an incoming class enters to replace them. Further, after completing the course, the early buyer values the good less than the incoming class. A non-renewable market of consumers would create some cannibalization of first period new-good sales, but the positive forces behind an imperfect secondary market would still exist. To better understand industries in which the market of consumers is non-renewable, further research could analyze the trade-off between this sales cannibalization and the value that the secondary market adds by expanding the product line in the second period and by increasing the willingness to pay in the first period.

Our results suggest that a secondary market should not only be tolerated by the manufacturer, but even supported. In some cases, the manufacturer should even discontinue new-good production in the second period, allowing only used-good sales in period two to maximize channel profit. While we model a monopolist manufacturer, this should not be a crucial assumption.[19] An imperfect secondary market will increase consumer willingness to pay and enhance profits in the first period, whether or not there are multiple manufacturers. Similarly, for differentiated products (such as textbooks), the manufacturer should be able to extract the additional profits gained by the retailer from re-selling the goods as used. A theoretical and empirical test of this prediction would be an interesting avenue for interesting future research.

Our research, along with that of prior researchers who model different kinds of markets, suggests interesting contrasting hypotheses concerning the profitability of used good markets. Our model contributes to the general theory about the effect of secondary markets on channel relationships and profitability. The results in this paper serve as a gateway for future empirical tests and theoretical generalizations.

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[19] The monopoly producer assumption is also used by Padmanabhan and Png (1997) in their model of returns product returns in the book market, reflecting the inherent differentiation among all books.

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