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Strategic Decentralization and Channel Coordination

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Abstract. In this paper, we show that under certain conditions, strategic decentralization through the addition of a retailer in the distribution channel can increase a manufacturer's profits. The specific case on which we focus is the quantity coordination (double marginalization) problem for a manufacturer selling durable goods in a two-period setting. We show that the standard solution that coordinates a channel for non-durables does not coordinate the channel for durables. In particular, even though a manufacturer can achieve channel coordination by offering per-period, two-part fees, the equilibrium wholesale price in the first period is strictly above the manufacturer's marginal cost. This is in stark contrast to the two-part solution for non-durables where the equilibrium wholesale price is equal to marginal cost. We also identify a strategy that solves both the channel coordination and the Coase problem associated with durable goods. In this strategy, at the beginning of period 1, the manufacturer writes a contract with the retailer specifying a fixed fee and wholesale prices covering both periods. We show that by adding a retailer and using this contract, the manufacturer makes higher profits than it could if it were to sell directly to consumers.

Key words. durable goods, channels of distribution, incentives

JEL Classification: L14, L22, M3

1. Introduction

Consider the following question: Can adding an intermediary to the marketing channel increase a manufacturer's profits? Most researchers would argue that unless the intermediary brings some specific skills that the manufacturer lacks (e.g., proprietary knowledge, access to customers, lower delivery costs, special retail locations, etc.), or the product market competition is very intense (McGuire and

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Staelin, 1983), adding a layer in the distribution channel would simply increase channel inefficiencies. Indeed, the focus of a very large literature on channel coordination is to identify ways by which a decentralized manufacturer can mitigate these inefficiencies and achieve the same profit as a centralized manufacturer. In this paper, we show that under some conditions, an integrated durable goods manufacturer can increase profits by decentralizing and adding a retailer to the distribution channel. This can occur even when the retailer brings no unique marketing skills to the table or there is no product market competition.

Analyzing the problem of selling a durable good through an intermediary is complex because not only does the manufacturer have to deal with the channel coordination problem, but it also has to deal with the inter-temporal problem associated with selling durable goods. While prior work has separately analyzed these two problems, it has not addressed them in settings where both problems need to be solved simultaneously. In this paper, we simultaneously address both these problems and, in the process, integrate the durable goods as well as the channel coordination literatures.

Beginning with Coase (1972), a large literature has studied the inter-temporal problem faced by durable goods manufacturers and the negative impact it has on profits (see, for example, Bulow, 1982; Stokey, 1981).[1] Coase argued that a monopoly seller of an infinitely lived durable would not be able to sell output at the static monopoly level. In particular, once the initial quantity had been sold, the monopolist would always have an incentive to lower price and sell additional units. Coase conjectured that consumers with rational expectations would force the monopolist to lower prices to the competitive level right from the start. This erosion of monopoly power because of an inability to keep prices high is referred to as the Coase problem. Subsequent research in this area has focused largely on ways in which this problem can be solved or conditions under which it can be mitigated (see, for example, Conlisk et al., 1984; Bond and Samuelson, 1984; Kahn, 1986; Bagnoli et al., 1989; Butz, 1990; Fehr and Kuhn, 1995).

A well-recognized solution for this problem is for the firm to rent, rather than sell the product to consumers. When the firm rents the product, it retains ownership of used units, and therefore, has an incentive to keep the price of used units high, thus evading the Coase problem entirely. Although renting gives the appropriate incentives to the firm to keep prices high, note that renting can potentially create certain additional problems. For example, as Tirole (1988) and Fudenberg and Tirole (1998) point out, concerns about consumers potentially abusing the product may prevent a firm from renting. In addition, renting can become unattractive if the firm faces substantial remarketing costs each time a unit is rented to consumers (Huang et al., 2001). Finally, renting may involve the added cost of writing legal contracts with individual consumers. As a result, renting may not always be feasible or profitable. In this paper, we focus our attention on markets where renting is infeasible due to some of the reasons outlined above.

1 For a good review of the Coase problem in durable goods, see Tirole (1988).

The channel coordination literature studies a manufacturer's problem of designing contracts that give the retailer incentives to choose the appropriate level of price, service or other marketing decisions (see, for example, Spengler, 1950; Jeuland and Shugan, 1983; McGuire and Staelin, 1983; Moorthy, 1987; Lal, 1990; Rao and Srinivasan, 1995; Lal et al., 1996, Villas-Boas, 1998, among others).[2] An important insight from this literature is that a manufacturer can solve the price coordination or double marginalization problem by choosing a two-part contract in which the wholesale price is set at the manufacturer's marginal cost, and the fixed fee extracts all the profits over the minimum amount needed to retain the participation of the retailer. Said differently, the manufacturer solves the price coordination problem by selling the firm to the retailer at a cost equal to the fixed fee.

The durable goods problem has been analyzed largely within the context of a manufacturer marketing directly to the consumers, and the channel coordination literature has focused on static models that are appropriate for analyzing non-durable goods. A priori, it is not clear if the solution to the coordination problem for non-durables should also apply to durable markets in which inter-temporal considerations play an important role. For example, manufacturers and retailers of durables create their own future competition. Specifically, if consumers have the option of buying used goods instead of new ones, then new goods sold today become used goods that compete against future sales of new goods. Therefore, in the case of durable products, the manufacturer has to structure its contract with the retailer so that it can coordinate the channel and manage the competition from the secondary market.

1.1. Overview of model and results

We develop a dynamic, two-period model in which a manufacturer sells its products to a retailer who then sells it to consumers. Products sold in the first period become used goods in the second period and compete with new units. Starting from consumer utilities, we build inverse demand functions for new and used goods. Given the well-established results from the existing channel coordination literature, we begin with a contract in which the manufacturer offers a two-part contract at the beginning of each period. The two-part contract that coordinates the channel is such that the manufacturer charges a wholesale price strictly greater than its marginal cost in the first period, and charges a wholesale price equal to its marginal cost in the second period. Thus, unlike the case for non-durables in which the manufacturer sells at marginal cost, for durables, the manufacturer continues to charge above marginal cost and retains a stake in the firm.

Although this two-part contract solves the coordination problem and total channel profits with this contract are the same as an integrated manufacturer's profit

2 This is only a representative list.

when it sells directly to consumers, it does not solve the Coase problem. Subsequently, we show that by pre-committing to a two-part contract that covers both periods, the manufacturer can also solve the Coase problem. Interestingly, in this contract, the manufacturer charges a wholesale price above marginal cost in both periods and earns higher profits by selling through a retailer than by selling the product directly to consumers. When the manufacturer employs this contract, total channel profits are identical to the channel profits when the manufacturer rents its products directly to consumers. These are the highest level of profits that a durable goods distribution channel can achieve—either by renting or by selling. Said differently, this contract solves not only the channel coordination problem, but also the Coase problem.

Our paper makes contributions to both the durable goods as well as the channel coordination literatures. We contribute to the durable goods literature by showing how a durable goods manufacturer can sell its product and still solve the Coase problem. Effectively, this allows the manufacturer to earn the same profits as it would get if it could rent its product. When renting all the units is not feasible or profitable because of moral hazard (Fudenberg and Tirole, 1998) or remarketing costs (Huang et al., 2001), our solution provides another way of achieving the first-best outcome for a durable goods manufacturer. We contribute to the channel coordination literature by showing that the inter-temporal link in a durable good's market changes the channel coordination problem. Importantly, we show that under some conditions, the retailer may have incentives to sell too much rather than too little. As a result the manufacturer is better-off charging a wholesale price that is higher than its marginal cost.

The remainder of this paper is organized as follows: In Section 2, we describe the model and present the analysis in Section 3. We conclude the paper in Section 4.

2. Model

We develop a model of a manufacturer selling a durable product to a retailer who sells the product to the consumers. We assume that the manufacturer produces the product at a constant marginal cost of production, $c > 0$. In order to market this product to consumers, the manufacturer uses a retailer who purchases units from the manufacturer and sells them to consumers. We assume that remarketing costs and moral hazard concerns preclude the retailer from renting the product to consumers. Other than the fees paid to the manufacturer, we assume that the retailer's marginal costs are constant, and set them to zero without further loss of generality.

Following Bulow (1982), we assume that the durable product provides two periods of service.[3] However, unlike Bulow (1982, 1986) in which the manufacturer sells

3 Assuming the product lasts for two periods is equivalent to assuming that it becomes obsolete after n periods. It is only important to assume that the product last for a finite amount of time (Bulow, 1982).

directly to consumers, we model a distribution channel in which the manufacturer sells its product through an intermediary. In our model, a unit sold in period 1 provides service in periods 1 and 2. In addition, we assume that after a consumer purchases a new unit in period 1, the product deteriorates with usage and becomes a used good in period 2. The extent of deterioration depends on the inherent durability, $\delta(1 \geq \delta \geq 0)$ of the product. That is, δ represents how well a unit sold in period 1 holds up in period 2, and $(1-\delta)$ represents the extent of deterioration due to usage. If $\delta = 1$, the product does not deteriorate and new units are identical to used units. If $\delta = 0$, then the product has no durability and it deteriorates fully after one period of use.

An implication of product durability in our model is that consumers who purchase the product in period 1 have the option of selling their used product in the secondary, or used, market in period 2. We assume that the used market is competitive and neither the manufacturer nor the retailer has any direct control over this market. As a consequence, used goods compete against new goods and the extent of competition between new and used units is directly related to the durability δ. If the product is perfectly durable $(\delta = 1)$, then new and used units are identical and new goods face the strongest competition from used goods. On the other hand, if the product is a non-durable (i.e., $\delta = 0$), the issue of a used market is moot.[4]

We assume that consumers value a product for the services that it provides. Because a new unit provides service that is different from a used unit, consumers value a new unit more than a used unit. We derive per-period prices for the product based on consumers' valuations for the services provided by the product in a given period. Define r_{ij} as the one-period price in period i of product j, where $i = 1, 2$ and j, can either be new (n) or used (u). Consumers who purchase the product in period 1 get the right to enjoy two periods of service from the product—first as a new good and then as a used good. The selling price of the new product in period 1, p_{1n}, should reflect all future service that the product will provide. Therefore, $p_1 = r_{1n} + \rho r_{2u}$, where $0 < \rho < 1$ is a discount factor common to consumers and the firm.

We assume that in each period the retailer chooses a certain quantity to sell in the market. These quantities determine the retail prices based on the following inverse demand system:

$$r_{1n} = \alpha - q_{1n}, \tag{1}$$

$$r_{2n} = \alpha - \delta q_{2u} - q_{2n}, \tag{2}$$

$$r_{2u} = \delta(\alpha - q_{2n} - q_{2u}), \tag{3}$$

4 Our formulation is also different from Bulow (1982, 1986) in how we model deterioration. In Bulow (1982), the goods do not deteriorate and used products are as good as new ones, while Bulow (1986) assumes that a certain fraction of units sold in period 1 decay completely while the remaining used units are as good as new units.

where α is an arbitrary positive constant and q_{ij} is the quantity sold in period i of product j. A product that is sold by the manufacturer (or retailer) to consumers in period 1 becomes a used product in period 2, i.e., $q_{2u} = q_{1n}$. We show in the Appendix that the above demand functions are derived from a well-specified consumer utility function. Because there are no used products available in period 1, we do not have an r_{1u}. As δ increases, used goods deteriorate less and are closer substitutes for new goods; therefore r_{2u} increases and r_{2n} decreases with δ. Similarly, the quantity of used products (q_{2u}) negatively affects the new product price in period 2, r_{2n}. Since new products deliver a higher quality of service, their price is also higher, $r_{2n} \geq r_{2u}$.

The manufacturer in our model is assumed to play the role of a Stackelberg leader who announces a contract to the retailer. Based on this contract, the retailer chooses the number of units to order and sell on the market. We have also analyzed another formulation in which the retailer chooses prices rather than quantities and have found that our qualitative results remain unchanged. Finally, to rule out uninteresting cases, we restrict our attention to those parameter values for which the quantities sold in each period are strictly positive.

3. Analysis

An integrated manufacturer has the choice of either renting or selling its product to consumers. Because the relative profitability of these strategies is well established (e.g., Bulow, 1982), we simply note that in the absence of consumer moral hazard and additional marketing costs, renting is more profitable for the manufacturer than selling. In fact, renting represents the first-best profit that the manufacturer can achieve in an integrated channel.

We now consider the case of a manufacturer that has to rely on the services of a retailer to distribute its product to consumers. In particular, the retailer purchases the product from the manufacturer and sells it to consumers. Within this channel structure, we examine two different contracts that the manufacturer can offer to the retailer. In the first contract, we assume the manufacturer does not have the ability to commit to a long-term contract that covers both periods. In the second contract, we assume the manufacturer can commit to a long-term contract.

3.1. Two-part contract without commitment

A well-known result from the channel coordination literature is that a two-part contract, made up of a lump sum fixed fee and a constant per-unit wholesale price, solves the double marginalization problem. In this coordinating contract, the manufacturer sets the wholesale price at marginal cost and extracts all the surplus profit from the retailer through the fixed fee. Below, we explore whether such an approach can solve the problem of managing a durable goods channel. We require that any contract must offer non-negative profit to the retailer for it to be acceptable to the retailer.

We solve this model beginning with the retailer's problem in period 2. The retailer's period 2 profits are given by, $\pi_{D2} = (r_{2n} - w_2)q_{2n} - F_2$, where w_2 is the second-period wholesale price and F_2 is the second-period fixed fee. The retailer maximizes second-period profits by choosing the optimal q_{2n}. This yields

$$q_{2n}^* = \frac{\alpha - w_2 - \delta q_{1n}}{2}.$$

Based upon this choice, the manufacturer maximizes its profits in period 2,

$$\pi_{M2} = (w_2 - c)q_{2n} + F_2$$

by choosing the optimal w_2 and F_2. This yields $w_2^* = c$ and an F_2^* that extracts all the retailer's profits in period 2.

The retailer's problem in period 1 is to maximize profits over the two-period horizon,

$$\Pi_{D1} = (p_{1n} - w_1)q_{1n} - F_1 + \rho\Pi_{D2}^*,$$

where w_1 is the first-period wholesale price and F_1 is the first-period fixed fee. This yields the optimal quantity in period 1:

$$q_{1n}^* = \frac{2\alpha + \delta\rho(\alpha + c) - 2w_1}{4 + 2\delta\rho(2 - \delta)}.$$

Based on the retailer's optimal choice, the manufacturer maximizes profits,

$$\Pi_{M1} = (w_1 - c)q_{1n}^* + F_1 + \rho\Pi_{M2}^*.$$

The optimal period 1 wholesale price, w_1^*, and fixed fee, F_1^*, that result from this optimization are:

$$w_1^* = \frac{\alpha\delta\rho[4 - 3\delta^2\rho - 2\delta(1 - 2\rho)] + c[8 + 4\delta\rho + \delta^3\rho^2 - 4\delta^2\rho(1 + \rho)]}{8 + 2\delta\rho(4 - 3\delta)}, \tag{4}$$

$$F_1^* = \frac{2(2 + 2\delta\rho - \delta^2\rho)[\alpha - c(1 - \delta\rho)]^2}{(4 + 4\delta\rho - 3\delta^2\rho)^2}. \tag{5}$$

Note that for any $\delta > 0$, the optimal wholesale price in period 1 is greater than marginal cost, $w_1^* > c$. When $\delta = 0$, then the product we are considering is a non-durable, and we get the standard result of marginal cost pricing, $w_1^* = c$. Based on the optimal contract offered by the manufacturer, the retailer's optimal quantities are given by:

$$q_{1n}^{*} = \frac{2[\alpha - c(1-\delta\rho)]}{4 + 4\delta\rho - 3\delta^{2}\rho}, \tag{6}$$

$$q_{2n}^{*} = \frac{\alpha[4 - 3\delta^{2}\rho - 2\delta(1-2\rho)] - c[4 - 2\delta(1-2\rho) - \delta^{2}\rho]}{2(4 + 4\delta\rho - 3\delta^{2}\rho)}. \tag{7}$$

It is important to note that the quantities in equations (6)–(7) are exactly the same as those that an integrated seller would choose.

We summarize our results with the following proposition:

Proposition 1: *There exists a two-part tariff that coordinates the distribution channel. In this contract, the manufacturer charges $w_1^* \geq c$ in the first period and $w_2^* = c$ in the second period. The manufacturer's profit is equal to that of an integrated manufacturer selling directly to consumers.*

Thus, similar to the case of non-durables, there exists a two-part contract that coordinates the distribution channel for a durable product. However, there is an important difference—the manufacturer sells at marginal cost only in period 2; in period 1, it sells strictly above its marginal cost. Recall that the standard channel coordination problem for non-durables is that the retailer sells a quantity that is too low from the manufacturer's point of view. As a result, the manufacturer lowers its wholesale price to marginal cost and aligns its interests with the retailer's. On the other hand, when it comes to durable products, aligning the manufacturer's and retailer's incentives comes through a wholesale price above marginal cost. That is, the manufacturer's contract is designed to induce the retailer to sell a lower and not a higher quantity.

To understand this result, note that in period 1, any increase in the number of units sold reduces the second-period prices of new and used goods. This suggests that the retailer may have an incentive to reduce sales in period 1 in order to preserve the market and increase its profitability in period 2. However, the manufacturer can observe the retailer's choices in period 1 and extract all of the retailer's second-period profit through the fixed fee, F_2^*. In other words, the manufacturer can make the level of the second-period fixed fee conditional on the retailer's first-period choices. In effect, this means that the retailer has no stake in the outcome of period 2 and, thus, does not care about restricting quantities in period 1. On the other hand, the manufacturer, through its stake in second-period profits, F_2^*, still very much cares about period 2. If the manufacturer sets the first-period wholesale price at marginal cost, the retailer chooses a first-period selling quantity that is too high from the manufacturer's point of view. Therefore, the manufacturer increases the first period wholesale price above the marginal cost to induce the retailer to choose a lower quantity in the first period. This lower quantity preserves the market in period 2 and increases profitability.

Bulow (1982) suggests that investing in inefficient technology and having a higher marginal cost could help a monopolist signal to consumers its intentions to keep prices high in the future, thus alleviating the Coase problem. Because the retailer in our model faces a wholesale price above marginal cost, the retailer in our model may seem committed to a high cost structure like Bulow's monopolist. However, that is not the case. In particular, the retailer in our model faces a situation that is exactly the opposite of the situation faced by Bulow's monopolist. Bulow's monopolist has a stake in the second period and it worries about the effect of first-period quantity on the second-period outcome. On the other hand, depending on the level of second-period fixed fees, the retailer in our model can have no stake in the second-period and may not be concerned about how its first-period quantity choice affects the second-period outcome. It is for this reason that our retailer has an incentive to sell too much in the first period rather than an incentive to sell too little. Importantly, the wholesale price in our model is not a solution for the retailer's inability to commit to a higher future price; rather, it is a way for the manufacturer to induce the retailer to choose a lower quantity.

Although the two-part tariff outlined above effectively coordinates the distribution channel to the level of an integrated seller, the channel as a whole still suffers from the same Coase problem that an integrated seller of a durable good would face. This suggests that if it can solve the Coase problem, the manufacturer can increase its profits. As shown above, the manufacturer's goal of extracting all of the retailer's profits in period 2 creates additional incentive problems. If the manufacturer could commit not to engage in such behavior, it could eliminate this additional incentive problem. Therefore, we now consider another contract in which the manufacturer can commit to the second-period contract at the beginning of the first period.

3.2. Two-part contract with commitment

In the previous section, the manufacturer announced its period 2 contract at the beginning of period 2. Because the second-period contract is conditional on the retailer's first-period choice, a strategic retailer makes choices that lead to the result outlined in Proposition 1. Therefore, the only way for the manufacturer to convince the retailer that it will not extract all the retailer profits in period 2 is to commit to a contract before the retailer makes his first-period choice. In this section, we assume the manufacturer is able to make a credible commitment to the retailer regarding the contract. In other words, the manufacturer offers a contract that lays out the terms for both periods at the beginning of period 1 and then does not deviate from this commitment. To investigate the benefits of such a commitment, we now consider a contract in which the manufacturer specifies a single fixed fee and two wholesale prices.

The game is solved by first solving the retailer's problem in period 2, followed by its problem in period 1. Because this contract covers both periods, we require that it provide a non-negative profit to the retailer over the two period horizon. We solve the manufacturer's problem in period 1 by simultaneously choosing the optimal contracts for both periods. For the sake of brevity and because they are similar to the previous case, we do not present the intermediate steps.

The optimal quantities chosen by the retailer are as follows:

$$q_{1n}^{**} = \frac{\alpha - c(1-\delta\rho)}{2 + 2\delta\rho - 2\delta^2\rho}, \tag{8}$$

$$q_{2n}^{**} = \frac{\alpha(1-\delta)(1+\delta\rho) - c[1-\delta(1-\rho)]}{2 + 2\delta\rho - 2\delta^2\rho}. \tag{9}$$

The optimal wholesale prices and fixed fee are as follows:

$$w_1^{**} = \frac{\alpha\delta^2\rho + c(4 + 4\delta\rho + \delta^3\rho^2 - 5\delta^2\rho)}{4 + 4\delta\rho - 4\delta^2\rho}, \tag{10}$$

$$w_2^{**} = \frac{\alpha\delta + c(2-\delta)(1+\delta\rho)}{2 + 2\delta\rho - 2\delta^2\rho}, \tag{11}$$

$$F^{**} = \frac{\rho(\alpha - w_2^{**})^2}{4} + \frac{(\alpha - w_1^{**} + \rho w_2^{**}\delta)^2}{4 + 4\delta\rho - 3\delta^2\rho}. \tag{12}$$

The equilibrium quantities (equations (8)–(9)) sold by the retailer are exactly the same as those that an integrated renter would choose and result in the highest profits for the distribution channel. It is easy to see that $w_1^{**} \geq c$ and $w_2^{**} \geq c$ with the equalities holding only for $\delta = 0$ (the product is non-durable). Thus, when $\delta = 0$, our results reduce to the traditional result of marginal cost pricing for non-durables. We summarize our results with the following proposition:

Proposition 2: *A two-part contract with commitment coordinates the distribution channel and solves the Coase problem, thus achieving the highest level of profit. In each period, the optimal wholesale price is above the manufacturer's marginal cost.*

By committing not only to a specific fixed fee but also to specific wholesale prices, the manufacturer induces the selling retailer to choose the same quantities as an integrated renter. In the absence of the retailer, an integrated seller would not be able to choose these quantities without making credible commitments to individual consumers. It is often the case that a commitment to a single retailer is less costly, more credible and ultimately more enforceable than commitments to numerous individual consumers (e.g., Williamson, 1975; Barzel, 1982). In markets where this is likely to be the case, our analysis shows that having a retailer helps solve the Coase problem and allows the manufacturer to earn greater profits than it would if it were an integrated seller. Thus, even if renting is infeasible in a market, a manufacturer can still achieve the first-best profits of renting by selling through a retailer. Finally, we note that in this type of contract, selling the firm to the retailer (i.e., pricing at marginal cost) is also a feasible solution. However, it is not the equilibrium outcome because the manufacturer can do even better by charging wholesale prices above marginal cost.

3.2.1. Allowing renegotiation. In analyzing the commitment contract in the previous section, we assumed that the manufacturer maintained its contractual commitment. Consistent with the tradition in the contracting literature, we assume that the legal system is effective and efficient in remedying breach of contractual commitments by either party. However, one can argue that contract renegotiations may take place when such renegotiations can make both parties better-off. In this section, we briefly analyze how such contract renegotiations affect the profits of the two parties.

Given our sequence of events, it is clear that the only time renegotiation can occur is at the end of the first period, before the second-period decisions are made. That is, after q_{1n} has been sold but before q_{2n} is ordered from the manufacturer. The original contract is offered before the retailer chooses q_{1n}, hence there is no question of renegotiation before q_{1n} is chosen. After q_{2n} is chosen, no payoff-relevant actions are left in the game.

We now examine the benefits of renegotiation for the two parties. Taking the value of $q_{1n} = q_{1n}^{**}$ as given, we let the manufacturer choose a new wholesale price for the second-period and then let the retailer choose its optimal second-period quantity. We then derive the second-period profits for both parties with the new wholesale price, and compare them with the second-period profits from the (old) contract described in the previous section. This leads to the following:

Proposition 3: *When* $[(\alpha - c)(6 - 5\delta + 6\delta\rho) - (6\alpha - c)\delta^2\rho][(c - \alpha)(2 - 3\delta + 2\delta\rho) + (2\alpha + c)\delta^2\rho] < 0$, *the commitment contract is renegotiation proof. In this case, even though the manufacturer would be better-off with renegotiation, the retailer is strictly worse-off.*

Because contract renegotiation can make the retailer worse-off when $[(\alpha - c) \times (6 - 5\delta + 6\delta\rho) - (6\alpha - c)\delta^2\rho][(c - \alpha)(2 - 3\delta + 2\delta\rho) + (2\alpha + c)\delta^2\rho] < 0$, the original commitment contract is renegotiation-proof for the set of parameter values that satisfy this condition. For a given set of α, c, and ρ, the condition is violated only for relatively high values of δ. It is important to emphasize that in the relatively small range of δ where the condition may not be satisfied, the commitment contract would work only when there are other reasons preventing renegotiation.

It turns out that renegotiation is profitable to both parties if and only if the renegotiation leads the retailer to increase its second-period quantity, q_{2n}, above the level, q_{2n}^{**}, induced by the commitment contract. Note that this would occur only if the manufacturer lowered its wholesale price to a level below the originally contracted amount, w_2^{**}. This is the Coase problem revisited in the sense that the manufacturer and retailer have an *ex post* incentive to "flood" the market in period 2. If the retailer chooses $q_{2n} > q_{2n}^{**}$ as a result of renegotiation, the resulting prices in the used market in period 2 are lower than what the consumers expected them to be when they bought the product in period 1. This means that all buyers in period 1 paid a price that is too "high" given the new sales levels. Thus, in addition to the incremental profits associated with selling the static monopoly quantity in period 2, misleading or cheating first-period buyers also results in higher profits.

From this discussion, it should be clear that any renegotiation between the manufacturer and the retailer will harm all customers who bought the product in period 1. Another way of thinking about this is that by renegotiating terms, the manufacturer and the retailer have reneged on their terms with consumers. Importantly, some of the high valuation first-period buyers would be selling their used products and buying new ones in period 2 (see appendix for how this occurs). If we assume, as in Wernerfelt (1994), that consumers boycott a firm that misleads or cheats them, then any renegotiation would ensure that the second-period demand would drop to zero. Clearly, this would remove any incentives for renegotiation—even when the condition in Proposition 3 is not satisfied. It is important to highlight that any renegotiation in this model comes solely at the cost of being untruthful to customers. Any firm that is concerned about its long-term interests and reputation would clearly not favor an approach that relies principally on misleading its customers.[5] In the current model, note that the commitment contract earns the manufacturer the first-best profits associated with an integrated renter—it evades the Coase and channel coordination problems. Any renegotiation between the manufacturer and retailer would lead to profits above the first-best case. However, we are unlikely to see this arise for the reasons pointed out above.

4. Conclusion

When it comes to marketing non-durables, the best that a decentralized manufacturer can do is obtain the profits of an integrated manufacturer. On the other hand, a durable goods manufacturer can do even better by selling through a retailer—it can earn the same profits as an integrated renter. Prior research suggests that when renting is not feasible or profitable, a durable goods manufacturer has to suffer the inefficiencies caused by the Coase problem. In this paper, we offer a new and perhaps simpler way out of this problem for the manufacturer: sell the product through a retailer with an appropriate two-part contract. Even when renting is ruled out, the manufacturer can still solve its time-consistency problem with a specifically

5 More generally, the importance of maintaining a reputation for a durable goods monopolist has also been shown in Ausubel and Deneckere (1989).

designed two-part contract. This result shows that decentralization can serve as a strategic alternative to renting, and offers another potential explanation for why renting is not as widespread as theoretical predictions would suggest.

We also derive interesting insights about the channel coordination problem for a durable goods manufacturer. In the case of non-durables, the manufacturer's principal problem is that the retailer tends to pick a quantity that is too low from the manufacturer's point of view. As a result, the manufacturer achieves coordination by selling the product at its marginal cost. As we show in this paper, the coordination problem for durables is significantly different in that the retailer has an incentive to sell a quantity that is too high. Therefore, to induce the retailer to sell a lower quantity of the durable and align the incentives in the channel, the wholesale price exceeds the manufacturer's marginal cost. We also show that a manufacturer can gain by committing to future terms of trade with the retailer. The reason is that the channel coordination problem is worsened by the manufacturer's incentives to act opportunistically in the future. Once the retailer makes its first-period decisions, the manufacturer has an incentive to extract all the profits from the retailer in period 2. By making a contractual commitment not to act in such a way, the manufacturer solves the channel coordination and Coase problems.

In our analysis, our objective was to analyze if strategic decentralization can help a durable good manufacturer when renting is ruled out because of moral hazard or remarketing costs. Therefore, we assumed that the retailer sells all the units to consumers. We now briefly discuss what happens when the retailer can rent some or all the units. If we allow that possibility, it can be shown that with an uncommitted contract, the retailer prefers to sell all the units. As a result the manufacturer's optimal solution is exactly as outlined in Proposition 1. If we allow the manufacturer to make a contractual commitment, the manufacturer's profits are independent of the retailer's renting strategy. That is, the manufacturer earns the same profit regardless of the fraction of units that the retailer rents and this profit is the same as the first-best profit earned by the manufacturer in our Proposition 2. That is, allowing the retailer an option to rent as well as to sell does not improve or worsen the channel coordination problem. Thus, regardless of the availability of the renting option, the best that the manufacturer can do with a two-part contract without commitment is to achieve the same profit as the integrated seller. Similarly, the best that the manufacturer can do with a committed contract is to achieve the integrated renter's profit regardless of the availability of the renting option.

We find that the specifics of the contract vary with the inherent durability of the product and the extent of competition posed by the secondary market. Thus, product durability plays a crucial role in manufacturer relationships with retailers. We acknowledge that we have treated durability as an exogenous variable and assumed that there is no uncertainty about demand. Clearly manufacturers have some control over the durability that they build into a product and they often face uncertain demand. While McGuire and Staelin (1983) have shown how decentralization can help mitigate inter-brand competition, our results show how decentralization helps mitigate intra-brand competition. It may be interesting to fully investigate the role of retailers when manufacturers face both inter- and intra-brand competition. We leave these issues for future research.

Appendix: Derivation of demand functions

We model consumers who are heterogeneous in their valuations of the durable good. In this vertical differentiation model, we use the parameter $\phi \in (0, \alpha)$ to represent a consumer's valuation of the per-period service provided by a new product. Note that a consumer with a higher ϕ values the product more than a consumer with a lower ϕ. Finally, we assume that ϕ is distributed uniformly in the interval $[0, \alpha]$ and, in any period, each consumer uses at most one product. Recall from our discussion earlier that the product deteriorates as it ages. As a result, we assume that a consumer's valuation of the per-period services from a used product are $\delta\phi$.

The net utility from using a product for a single period is:

$$U = \delta^m \phi - r, \tag{A1}$$

where m is an indicator variable such that $m = 0$ if the product is new and $m = 1$ if the product is used, and r is the one-period price.

In equilibrium, consumers choose one of the following four strategies: (i) buy a new product in period 1 and, in period 2, sell their used product and buy a new product (BB); (ii) buy a new product in the first period and hold onto it in the second period (BH); (iii) remain inactive in period 1 and buy a used product in period 2 (IU); and (iv) be inactive in both periods (II). In terms of consumer utility, it can be shown that if all four strategies are observed in equilibrium, then consumers who follow a BB strategy value the product more (i.e., have a higher ϕ) than consumers who follow a BH strategy, who value it more than consumers who follow an IU strategy, who value it more than consumers who follow an II strategy.

In order to ensure subgame perfection, we begin by considering the consumers' utilities and prices in period 2. Following the notation in the text, let $q_{1n}(= q_{2u})$ and q_{2n} be the number of products sold in periods 1 and 2, respectively. Consider the lowest valuation consumer who adopts an IU strategy. This consumer is located at a point $\phi_3 = \alpha - q_{1n} - q_{2n}$ on the $[0, \alpha]$ line and has to be indifferent between following an IU and an II strategy. From equation (A1), this consumer's net utility from an IU strategy is $\delta(\alpha - q_{1n} - q_{2n}) - r_{2u}$, and the utility from following an II strategy is zero. Equating these two utilities, we get the following demand for used products:

$$r_{2u} = \delta(\alpha - q_{2u} - q_{2n}). \tag{A2}$$

Now consider the lowest valuation consumer who adopts a BB strategy. This consumer is located at a point $\phi_1 = \alpha - q_{2n}$ and has to be indifferent between BB and

BH strategies. In period 2, the net utility from a BB strategy is $\alpha - q_{2n} - r_{2n} + r_{2u}$.[6] Similarly, the net utility from holding onto the product in period 2 is $\delta(\alpha - q_{2n})$. Equating these two utilities yields the one-period price for new products in period 2:

$$r_{2n} = \alpha - q_{2n} - \delta q_{2u}. \tag{A3}$$

Now consider the consumers in period 1 and assume that they are making a decision about using the services of the product for a single period. The last consumer who uses a product in period 1 is located at a point $\alpha - q_{1n}$. This consumer has to be indifferent between using this product for one period and staying out of the market in this period. Equating the utilities from these two strategies yields the one-period price in period 1:

$$r_{1n} = \alpha - q_{1n}. \tag{A4}$$

Proofs of propositions

Proposition 1

An integrated seller's selling quantities, q^s_{1n}, q^s_{2n}, and profits, Π^s, are given by:

$$q^s_{1n} = \frac{2[\alpha - c(1 - \delta\rho)]}{4 + 4\delta\rho - 3\delta^2\rho},$$

$$q^s_{2n} = \frac{\alpha[4 - 3\delta^2\rho - 2\delta(1 - 2\rho)] - c[4 - 2\delta(1 - 2\rho) - \delta^2\rho]}{2(4 + 4\delta\rho - 3\delta^2\rho)},$$

$$\Pi^s = \frac{4(\alpha - c)^2 + 4\rho(\alpha - c)(\alpha + c(-1 + 2\delta)) + \delta\rho^2(4(\alpha - c)^2 + (c^2 + 6c\alpha - 3\alpha^2)\delta)}{16 + 4\delta\rho(4 - 3\delta)}.$$

These quantities are the same as outlined in equations (6) and (7) in the text. In addition, the integrated seller's profits are identical to the profits of the decentralized manufacturer charging a contract with $\{w^*_1, w^*_2, F^*_1, F^*_2\}$.

For the second-period sales, q^*_{2n} to be positive, $\alpha > c((4 - 2\delta + (4 - \delta)\rho\delta)/(4 - 2\delta + (4 - 3\delta)\rho\delta))$. With this restriction, any value of $\delta > 0$ also has $w^*_1 - c > 0$.

6 Recall that a BB strategy means that the consumer buys a new product in period 1, sells it at a price r_{2u} in period 2 and buys another new product at a price of r_{2n}.

Proposition 2

An integrated renter's quantity choices of q_{1n}^R, and q_{2n}^R, and profits, Π^R, are given by:

$$q_{1n}^R = \frac{\alpha - c(1-\delta\rho)}{2+2\delta\rho-2\delta^2\rho},$$
$$q_{2n}^R = \frac{\alpha(1-\delta)(1+\delta\rho) - c[1-\delta(1-\rho)]}{2+2\delta\rho-2\delta^2\rho},$$
$$\Pi^R = \frac{\alpha^2[1+(1-\delta)\rho](1+\delta\rho) + c^2[1+[1+\delta(-2+\rho)]\rho] - 2c\alpha[1+(1-\delta)\rho(1+\delta\rho)]}{4+4(1-\delta)\delta\rho}.$$

From equations (8) and (9), its clear that the $\{w_1^{**}, w_2^{**}, F^{**}\}$ contract results in $q_{1n}^R = q_{1n}^{**}$ and $q_{2n}^R = q_{2n}^{**}$. Similarly, the manufacturer's profits under this contract, Π^{**} are identical to the profits of an integrated renter, Π^R.

In addition, note that

$$w_1^{**} - c = \frac{\delta^2\rho[\alpha - c(1-\delta\rho)]}{4+4(1-\delta)\delta\rho} \tag{A5}$$

and

$$w_2^{**} - c = \frac{\delta[\alpha - c(1-\delta\rho)]}{2+2\delta\rho-2\delta^2\rho}. \tag{A6}$$

For the first-period quantity to be positive, $\alpha > c(1-\delta\rho)$. With this restriction, it is easy to see that $w_1^{**} > c$ and $w_2^{**} > c$.

Proposition 3

With the commitment contract, the retailer's second-period profit is given by

$$\Pi_{D2}^{**} = \frac{(\alpha(1-\delta)(1+\delta\rho) - c(1-(1-\rho)\delta)^2}{4(1+(1-\delta)\delta\rho)^2}.$$

The manufacturer's second-period profit under the same contract is given by

$$\Pi_{M2}^{**} = \frac{(\alpha(1-\delta)(1+\delta\rho) - c(1-(1-\rho)\delta))(\alpha - c(1-\delta\rho))\delta}{4(1+(1-\delta)\delta\rho)^2}.$$

After renegotiation, the retailer's second-period profit is given by $\widehat{\Pi}_{D2} = (\alpha - c - \delta q_{1n}^{**})^2/16$ and the manufacturer's second-period profit is given by $\widehat{\Pi}_{M2} = (\alpha - c - \delta q_{1n}^{**})^2/8$. After simplification, the manufacturer's gain from renegotiation is

$$\widehat{\Pi}_{M2} - \Pi_{M2}^{**} = \frac{(\alpha(2 - 3\delta + 2(1-\delta)\delta\rho - c(2 - 3\delta + \delta(2+\delta)\rho))^2}{32(1 + (1-\delta)\delta\rho)^2} > 0,$$

and the retailer's gain from renegotiation is

$$\widehat{\Pi}_{D2} - \Pi_{D2}^{**} = \frac{[(\alpha - c)(6 - 5\delta + 6\delta\rho) - (6\alpha - c)\delta^2\rho][(c - \alpha)(2 - 3\delta + 2\delta\rho) + (2\alpha + c)\delta^2\rho]}{64(1 + (1-\delta)\delta\rho)^2}.$$

It is easy to see that $\widehat{\Pi}_{D2} \gtrless \Pi_{D2}^{**}$ iff $[(\alpha - c)(6 - 5\delta + 6\delta\rho) - (6\alpha - c)\delta^2\rho]$ $[(c - \alpha)(2 - 3\delta + 2\delta\rho) + (2\alpha + c)\delta^2\rho] \lessgtr 0$.

References

Ausubel, L. and R. Deneckere. (1989). "Reputation in Bargaining and Durable Goods Monopoly", Econometrica 57, 511–531.

Bagnoli, M., S. Salant, and J. Swierzbinski. (1989). "Durable-Goods Monopoly with Discrete Demand", Journal of Political Economy 97(12), 1459–1478.

Barzel, Y. (1982). "Measurement Cost and the Organization of Markets", Journal of Law and Economics 25(1), 27–48.

Bond, E. and L. Samuelson. (1984). "Durable Good Monopolies with Rational Expectations and Replacement Sales", RAND Journal of Economics 15(3), 336–345.

Bulow, J. (1982). "Durable-Goods Monopolist", Journal of Political Economy 90(2), 314–332.

Bulow, J. (1986). "An Economic Theory of Planned Obsolescence", Quarterly Journal of Economics 101(4), 729–779.

Butz, D. (1990). "Durable-Good Monopoly and Best Price Provisions", American Economic Review 80, 729–749.

Coase, R. (1972). "Durability and Monopoly", Journal of Law and Economics 15(April), 143–149.

Conlisk, J., E. Gerstner, and J. Sobel. (1984). "Cyclic Pricing by a Durable Goods Monopolist", Quarterly Journal of Economics 99, 489–505.

Desai, P. and D. Purohit. (1998). "Leasing and Selling: Optimal Strategies for a Durable Goods Firm", Management Science 44(11), S19–S34.

Desai, P. and D. Purohit. (1999). "Competition in Durable Goods Markets: The Strategic Consequences of Leasing and Selling", Marketing Science 18(1), 42–58.

Fehr, N. and K. Kuhn. (1995). "Coase Versus Pacman: Who Eats Whom in the Durable Goods Monopoly", Journal of Political Economy 103(4), 785–812.

Fudenberg, D. and J. Tirole. (1998). "Upgrades, Trade-Ins, and Buybacks", RAND Journal of Economics 29, 235–258.

Huang, S., Y. Yang, and K. Anderson. (2001). "A Theory of Finitely Durable Goods Monopoly with Used-Goods Market and Transaction Costs", Management Science 47(11), 1515–1532.

Jeuland, A.P. and S.M. Shugan. (1983). "Managing Channel Profits", Marketing Science 2(3), 239–272.
Kahn, C. (1986). "The Durable Goods Monopolist and Consistency with Increasing Costs", Econometrica 54(2), 275–294.
Lal, R. (1990). "Improving Channel Coordination Through Franchising", Marketing Science 9(4), 299–318.
Lal, R., J.D.C. Little, and Miguel Villas-Boas. (1996). "A Theory of Forward Buying, Merchandising and Trade Deals", Marketing Science 15(1), 21–37.
Moorthy, K. (1987). "Managing Channel Profits: Comment", Marketing Science 6(4), 375–379.
McGuire, T. and R. Staelin. (1983). "An Industry Equilibrium Analysis of Downstream Vertical Integration", Marketing Science 2(2), 239–272.
Rao, R. and S. Srinivasan. (1995). "Why Are Royalty Rates Higher in Service Type Franchises?", Journal of Economics and Management Strategy 4(1), 7–31.
Spengler, J. (1950). "Vertical Integration and Anti-Trust Policy", Journal of Political Economy 58, 347–352.
Stokey, N. (1981). "Rational Expectations and Durable Goods Pricing", Bell Journal of Economics 12 (Spring), 112–128.
Tirole, J. (1988). The Theory of Industrial Organization. Cambridge, MA: MIT Press.
Villas-Boas, M. (1998). "Product Line Design for a Distribution Channel", Marketing Science 17(2), 156–169.
Wernerfelt, B. (1994). "On the Function of Sales Assistance", Marketing Science 13(1), 68–82.
Williamson, Oliver E. (1975). Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press.