REVENUE SHARING, DEMAND UNCERTAINTY, AND VERTICAL CONTROL OF COMPETING FIRMS

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ABSTRACT

This paper argues that revenue sharing is a valuable instrument in vertically-separated industries when there is intrabrand competition among the downstream firms, demand is stochastic or variable, and downstream inventory is chosen before demand is realized. In these environments, the upstream firm would like to simultaneously soften downstream competition and encourage efficient inventory holding. Traditional two-part tariffs cannot achieve both objectives in the presence of downstream competition. Raising the price of the inputs softens price competition but distorts the downstream firms' inventory decisions. We argue that revenue sharing, combined with a low input price, aligns the incentives in the vertical chain. The application of revenue sharing in video retailing is discussed.

Keywords: Vertical Separation, Vertical Restraints, Royalties, Revenue Sharing, Double Marginalization, Input Substitution, Demand Uncertainty.

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1. Introduction

Many supply contracts in vertically-separated industries include revenue-sharing agreements where the downstream firms make royalty payments to the upstream firm based upon the downstream sales revenue.[1] These output-based payments are often used in addition to payments for the upstream firm's goods or services -- the inputs in the downstream production process. This paper argues that revenue sharing is a valuable instrument in vertically-separated industries when there is intrabrand competition among the downstream firms, demand is stochastic or variable, and downstream inventory is chosen before demand is realized. In these environments, the upstream firm would like to soften downstream competition and encourage inventory holding. Without control over the downstream market structure, traditional two-part tariffs cannot exert a sufficient degree of vertical control. Raising the price of the inputs softens price competition but distorts the downstream firms' inventory decisions. We argue that revenue sharing, combined with a low input price, aligns the incentives in the vertical chain.[2]

The video rental industry provides a recent illustration of this idea. Many Hollywood movie studios have been changing the way they do business with video retail outlets. Traditionally, retailers like Blockbuster Video bought recently-released videotapes through a distributor for about $65 a copy and would keep all of the revenue

[1] These clauses might specify a percentage share (royalty) of the downstream firms' revenues or a fixed price per unit sold. While we focus on percentage shares in our models, analogous results are obtained for fixed prices.

[2] Many examples of revenue sharing appear in the literature, including sharecropping (Allen and Leuck, 1993), contingent fees for attorneys (Dana and Spier, 1993, and Rubinfeld and Scotchmer, 1998), franchising (see Bhattacharrya and Lafontaine, 1995, and the references therein), and licensing (see Shapiro, 1985, Gallini and Wright, 1990, and Beggs, 1992). A variety of rationales for these arrangements have been proposed,

from the subsequent rentals. Under this old system, customers were frequently "stocked out" and would either substitute towards a less popular title or would go home empty-handed. According to a Time Warner survey, 20% of customers were unable to rent their preferred video on a typical trip to the video store. Says Michael Johnson, the president of Buena Vista, Disney's video division, "It is like going into McDonald's, asking for your burger and getting french fries."[3] Under the newer system, videos are purchased by rental outlets for about $8 each and the rental revenue is shared: Blockbuster keeps 45% of the revenue, the movie studio gets 45%, and the remaining 10% goes to Rentrak, Blockbuster's distributor.[4] Under these revenue sharing deals, Blockbuster has increased its inventories of recent releases seven fold, and has launched a successful "Go Home Happy" marketing campaign, in which customers are guaranteed that a select list of videos will be in stock.[5]

The ideas here are related to the literature on vertical contracts when the factors of production are variable and downstream markets are competitive (see Warren-Boulton 1974 and Mallela and Nahata, 1980). While traditional two-part tariffs that set the transfer price above marginal cost soften downstream competition,[6] they also lead to a

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including two-sided moral hazard, risk allocation, capital constraints, price discrimination, and signaling.

[3] Shapiro (1998).

[4] Retailers typically must pay a high price, $67 for example, for any video that they report lost or stolen within 60 days of release. After the 60 days elapse, the video retailer typically may resell the used videos. "Rentrak Asks Retailers: Want a Bigger Cut?" *Video Business*, July 20, 1998. More recently, Blockbuster and other large retailers have bypassed Rentrak and are doing business directly with the movie studios. A similar system has been adopted for CD-ROM rentals. See "Comptons Tries Revenue Sharing for CD-ROM," *Billboard*, January 29, 1994.

[5] See Furman (1998).

[6] This idea is related to the problem that an upstream monopolist faces when selling a patented technology or licensing a brand name to downstream competitors. Selling

wasteful input distortions. Warren-Boulton (1974, 1977) argued that revenue sharing, together with marginal cost transfer pricing, solves both the input and the output distortions and implements the vertical integration. However, the input substitution problem is fundamentally different from the problem of choosing inventory under demand uncertainty and variability considered here.

Previous work considers vertical restraints and demand uncertainty when inventory must be set in advance, but does not discuss royalties or revenue sharing. Kandel (1996) and Marvel and Peck (1995) show that a monopolist selling to a single downstream firm can use returns contracts (or buybacks) to profitably increase downstream firms' inventory holding when two part tariffs are infeasible.[7] Padmanabhan and P'ng (1997) show similar results hold in a model with two downstream firms.[8] Our paper considers a perfectly competitive downstream markets and shows that revenue sharing serves a similar purpose. We argue that revenue sharing may be used in more general contexts such as when the upstream firm sells a capital good used to provide a downstream service.[9] Deneckere, Marvel, and Peck (1997) and Butz (1997, 1998) show that minimum resale prices limit price cutting in low demand states, and Deneckere, Marvel, and Peck (1996) show that resale price maintenance increases downstream firms'

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indivisible know-how to competitive downstream firms at a fixed price would lead them to dissipate rents, while a royalty on sales softens downstream competition and implements the collusive outcome. See Shapiro (1985).

[7] See also Pasternack (1985).

[8] Their contract does not achieve the vertical integration outcome because they prohibit lump sum transfers.

[9] Furthermore, revenue sharing is optimal in our paper even if the manufacturer could use lump sum transfers, as long as it cannot control downstream market structure

inventories.[10] However, resale price maintenance is still largely illegal in the United States while revenue sharing is typically permitted.

The paper analyzes two simple models. In the first model, demand is stochastic and downstream firms choose both prices and inventories before demand is known.[11] This captures the idea that there is a great deal of uncertainty about how popular a new title will be and prices do not fully adjust to market conditions. In the second model, demand is predictable but declining over time and prices are flexible. It is not unusual for video retailers to lower the rental price or increase the rental duration as movie titles age. Here, the upstream firm faces the problem of preventing destructive price competition during times of low demand.[12] The final section discusses other applications, including supply contracts in manufacturing, and offers concluding remarks.

2. Inventory Holding with Demand Uncertainty and Sticky Prices

The upstream monopolist offers a contract $\{t, r\}$ to the competitive downstream firms, where t is the transfer price per unit of capacity and r is the royalty rate on total revenue.[13] The monopolist's cost of capacity is $c > 0$ per unit of capacity and the

[10] See also Scotchmer (1987).

[11] This is a version of a "newsboy" problem, and is based on Carlton (1978) and Deneckere and Peck's (1995).

[12] In other words, it would like to commit the downstream firms to destroy their inventories or waste their capacity. This idea is based on the model of Deneckere, Marvel, and Peck (1997) where the upstream firm is trying to control the price in more than one demand state.

[13] Formally we ignore the possibility of lump-sum transfers. No firm would be willing to pay an up front fee because the market is perfectly competitive and all downstream rents are dissipated in equilibrium.

incremental downstream cost of goods sold is $d > 0$. Before the state of demand is known, the downstream firms simultaneously decide how much capacity to purchase under the terms of this contract and set their prices. Prices are assumed to be "sticky" -- they cannot subsequently adjust to market conditions.[14]

We take as given that the downstream market is perfectly competitive and show that the upstream firm is able to implement the vertical integration outcome with the contract $\{t, r\}$. Although video retailers often face local competition from other retailers, they typically retain at least some power over price. While the assumption that the downstream environment is perfectly competitive is extreme, it allows us to explore some important effects of revenue sharing agreements. If we allowed explicitly for lump-sum transfers in our model, then the upstream firm could also implement the vertical integration outcome with a single downstream firm.

There are, however, other reasons why it may not make sense for movie studios to adopt an exclusive relationship with one video retailer. First, given the incomplete nature of contracts, it might be difficult for the upstream firm to commit to deal with just one retailer. After entering into a contract with one retailer the upstream firm would have an incentive to cannibalize that retailer by contracting with a second. See Hart and Tirole (1990), O'Brien and Shaffer (1992), and Alexander and Reiffen (1995). Second, the video retail industry is characterized both by some degree of geographic differentiation and by strong consumer demand for variety and selection (so video retailers distribute the

[14] This model is a simple version of Carlton (1978), and closely follows Deneckere and Peck's (1995) specification (i.e. unit demand) which extends Carlton's model by considering imperfect competition.

movies of many different studios). By dealing exclusively with one retailer a movie studio may restrict the market for its releases.

The demand state is characterized by the number of active consumers, x, where x is drawn from a distribution $f(x)$ on support $[0,\infty)$. $F(x)$ is the cumulative distribution function and $\bar{x}$ is the mean. Although consumers do not *directly* observe the state of demand, they do draw rational inferences from being active in the market and decide where to shop on the basis of price and expected availability. Once in a store, consumer will purchase an available unit if and only if his valuation, V, exceeds the price, P, and we assume that $V > d + c$. If a customer goes to a store that is out of stock, the customer will "Go Home Unhappy" -- there is no opportunity to search further after the initial round.[15]

Following the literature, we characterize uniform price equilibria where the downstream market supplies K units of capacity at a market price $P \leq V$. In equilibrium, the expected number of units sold as a function of K is:

$$S(K) = \int_0^K x f(x) dx + \int_K^\infty K f(x) dx. \tag{2.1}$$

If the number of consumers in the market, x, is smaller than K, then x units will be sold. If, on the other hand, demand outstrips available capacity, $x > K$, then there will be

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[15] This assumption of infinite search costs simplifies the analysis. If we allowed additional rounds, then firms could specialize in high price/high availability, and the equilibrium would be in mixed strategies. Alternatively, we could have specified a model where consumers had zero search costs. In that case, downstream competition would yield price dispersion. First described by Prescott (1975) and extended in Dana (1998), this model is used in Deneckere, Marvel and Peck's (1996) model of resale price maintenance and would yield very similar results here.

rationing (a "stock out") and K units will be sold. An implicit assumption here is that consumers are very small relative to firms and are evenly distributed among them. In equilibrium either all of the competitive firms stock out or none of them do. Differentiating this expression,

$$S'(K) = 1 - F(K) < 1\,. \tag{2.2}$$

When capacity increases by one unit, the expected sales increase by less than one unit. Intuitively, this is because the marginal unit will only sell when demand is sufficiently high, $x > K$, which happens with probability $1 - F(K)$. $1 - F(K)$ is also known as the firm's "stock out rate" -- the probability that demand will exceed the available supply.

As a benchmark, we first characterize the outcome, $\{P^*, K^*\}$, that creates the greatest total value in the vertical chain. A vertically integrated structure would choose P^* and K^* to maximize profits, $(P - d)\,S(K) - cK$, subject to the constraint that consumers are willing to purchase the good, or $P \leq V$. Clearly this constraint binds, so the price extract all of the consumer surplus,

$$P^* = V. \tag{2.3}$$

Differentiating the profit function with respect to K and using (2.2), we see that capacity expands to the point where

$$(V - d)\,[1 - F(K^*)] - c = 0\;. \tag{2.4}$$

In other words, a vertically integrated firm sets the expected marginal return from an additional unit of capacity, $(V - d)[1 - F(K^*)]$, equal to the marginal cost of capacity, c.

Notice that this vertical-integration outcome, $\{P^*, K^*\}$, also maximizes social welfare since the expected social return from an additional unit of capacity is precisely $(V-d)\,[1-F(K^*)]$. This property arises because consumers have unit demands (so there is no consumer dead-weight loss) and the monopolist extracts all of the consumer surplus.

Now suppose instead that the industry is vertically separated and that the downstream firms purchase capacity and set prices given the contract $\{t, r\}$. Consumers care about both price and availability, and opt to visit firms that offer the best combination. In a uniform price equilibrium, a consumer's probability of being served (conditional upon his being active in the market), also known as the "service rate," is equal to the total expected sales divided by the expected number of consumers:[16]

$$R(K) = \frac{S(K)}{\bar{x}}. \tag{2.5}$$

The representative consumer's expected surplus conditional upon being in the market, is the consumer surplus conditional upon purchasing the good, $V - P$, multiplied by this service rate, $R(K)$, or

$$U(P,K) = (V-P)\frac{S(K)}{\bar{x}} \ . \tag{2.6}$$

[16] See Deneckere and Peck (1995).

The competitive equilibrium, $\{\widetilde{P}, \widetilde{K}\}$, maximizes consumer surplus (2.6) subject to the zero-profit condition for the downstream firms,[17]

$$[(1-r)P-d]\ S(K)-t\,K=0. \tag{2.7}$$

The aggregate downstream profit is simply the profit margin on each unit sold, $[(1-r)P-d]$ multiplied by the total expected sales, $S(K)$, less the cost of capacity, *tK*.

Solving (2.7) for *P* as a function of *K* and substituting the expression into (2.6) simplifies the program and, using (2.2), yields the following first-order condition for $\widetilde{K}$:

$$\left(V-\frac{d}{1-r}\right)[1-F(\widetilde{K})]-\frac{t}{1-r}=0\ .^{18} \tag{2.8}$$

The equilibrium capacity $\widetilde{K}$ may be understood intuitively. Given a contract *{t, r}*, the competitive market expands capacity until the expected "social value" of an additional unit of capacity is exactly offset by the "social cost" of capacity, where the social value and cost are *net* of payments made to the upstream firm (these payments are sunk).

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[17] See Carlton (1978). Deneckere and Peck (1995) show that this characterization of a competitive market equilibrium is the limit of the unique pure strategy equilibrium of a symmetric oligopoly game as the number of firms goes to infinity. In their model firms simultaneously announce prices and capacities and consumers, given these, decide which firm to visit. Of course a consumer's choice also depends on other consumers' decisions. They define a consumer equilibrium as a mixed strategy for consumers such that if each consumer mixes over firms in the given proportion then consumers are indifferent among all of the firms that are visited with positive probability in equilibrium. They show that a unique consumer equilibrium exists whenever firms choose prices and capacities that constitute undominated strategies. Deneckere and Peck then show that their game has a unique pure strategy equilibrium when number of firms is sufficiently large, and that as the number of firms approaches infinity the equilibrium approaches the perfect competitive equilibrium characterized above. Firms earn zero profits and maximize consumer surplus.

[18] Multiplying this expression by $(1-r)$ shows that there is a linear relationship between *t* and *r* where a reduction in *t* by Δ must be offset by an increase of $\Delta V[1-F(K^*)]$ in *r*.

Comparing $\widetilde{K}$ from (2.8) to K^* from (2.4) shows that the costs d and t are now "inflated" to reflect the revenue share paid to the upstream monopolist.

This comparison also highlights how valuable revenue sharing can be. If there were no royalty, so $r = 0$, then comparing (2.8) to (2.4) shows that $t = c$ would implement the (privately) optimal capacity choice, $\widetilde{K} = K^*$. However, this contract leads the competitive firms to price too low and generates no profits for the upstream monopolist. The upstream firm could extract some profits by raising the price of capacity, t, but by comparing (2.8) to (2.4) we see that the competitive downstream firms would distort their capacity choices and hold $\widetilde{K} < K^*$. Instead, the upstream firm should simultaneously lower the transfer price, t, below c and raise the royalty, r, above zero. In this way, the monopolist can maintain the incentives for the competitive downstream market to hold capacity K^*. In the extreme, as t approaches zero and r approaches $(V-d)/V$, the market price converges to P^*, and the upstream firm earns monopoly profits.

Proposition 1: The vertical-integration outcome is implemented with the revenue-sharing contract $\left\{0,\ \frac{V-d}{V}\right\}$.

One feature of the optimal contract is that the downstream retailers are indifferent over their choice of inventory. The optimal contract allows the downstream firm to obtain inventory freely but then extracts all the profits from downstream sales through the royalty, which acts like a 100% profit tax. This result gives the misleading impression that revenue sharing works only because it creates this indifference.

Suppose that downstream firms have agency costs and need to be motivated to provide other services. For simplicity suppose that the downstream firms have some unobservable alternative use for the good which earns $\underline{t}$ per unit. Then the upstream firm is constrained to offer a contract in which $t \geq \underline{t}$. At the constrained optimum downstream firms are no longer indifferent over inventory and it is easy to show that in the limit as $\underline{t} \to 0$, the constrained optimal contract implements the same capacity and profit as the unconstrained contract.[19]

It is interesting to note that social welfare is unambiguously higher with revenue sharing in this model. As mentioned earlier, if the monopolist were restricted to use a contract with $r = 0$, then any contract with $t > c$ will lead the downstream firms to hold $\tilde{K} < K^*$, too little capacity from a social welfare perspective.

If royalty arrangements were prohibited or too difficult to implement, then the upstream monopolist might try to get around these distortions in other ways.[20] One way might be to try to commit to deal with only one downstream firm, transfer at $t = c$, and use a franchise fee or lump sum transfer to extract the monopoly profits. Alternatively, the upstream firm might adopt other vertical restraints such as resale price maintenance and returns contracts. However, resale price maintenance is illegal and returns contracts tend to be better suited to inventories and pure resale. When the downstream firms buy videos from movie studios and rent them to consumers (or more generally buy a capital

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[19] Consider the contract $\left\{\underline{t}, \left(V - d - \frac{\underline{t}}{1 - F(K^*)}\right)\middle/ V\right\}$. This is the constrained contract that implements K^*. The optimal constrained contract can do no worse, yet clearly as $\underline{t} \to 0$ this contract approaches the unconstrained contract characterized in Proposition 1.

[20] In the video rental industry, revenue sharing was made possible by the development of sophisticated computer systems that would accurately track video rentals.

good and offer services to their consumers) the upstream firm cannot use a simple returns contract to acquire useful information about the frequency with which retailers rent the videos. What the upstream wants is a technology that monitors how many times each of its videos has been rented. But this technology may render the physical return of the videos tapes obsolete and make revenue sharing the superior vertical restraint.

3. Destructive Competition with Declining Demand and Flexible Prices

As in the previous section, the upstream monopolist offers contract *{t, r}* to the downstream firms, where *t* is the transfer price per unit of capacity and *r* is the royalty rate on revenue. The downstream firms make their capacity decisions at the beginning of time, and prices are allowed to subsequently adjust to market conditions. Time is continuous and is indexed by $s \in [0,\infty)$, and all agents discount time at a common rate, $\rho > 0$. Demand is predictable but falling over time, and is given by $P = 1 - Q / x(s)$, where $x(0) = \bar{x} > 0$, $x'(s) < 0$, and *x(s)* approaches zero in the limit. We can interpret this demand specification as representing a perishable good or service with a declining mass of homogeneous customers, *x(s)*, each with downward sloping demand $P = 1 - Q$. (Alternatively, we could easily adapt the model to consider peak load demand, such as weekend video rentals, without changing the results.) The upstream cost of capacity is $c > 0$ per unit, and each unit of capacity allows the downstream firms to "rent" one unit of a final good at incremental cost $d > 0$ per unit time.

There are important differences between this model and the model from the previous section. First, now we allow downstream prices to fully adjust to market conditions. Second, we assume that customers are free to search for the lowest price.

These assumptions imply the firms are essentially Bertrand price competitors and markets clear at each point in time, so customers no longer care about availability directly. Another noticeable difference between these two sections is that now demand is declining in a predictable way. This distinction is more cosmetic than substantive, however. We could easily reinterpret this dynamic model as representing demand uncertainty instead. Letting demand change over time is interesting because time-varying demand (declining popularity and peak demand on weekends) is an important characteristic of our service and rental industry applications.

As a benchmark, suppose that the industry is vertically integrated. Given capacity, K, what is the integrated firm's strategy? In later periods, available capacity exceeds demand and the firm simply sets the marginal revenue of a rental, $1-2Q/x(s)$, equal to the incremental cost of a rental, d. The quantity sold during these later periods is $Q(s)=x(s)(1-d)/2$. During early periods, however, the capacity constraint will bind. The cutoff between these two regimes, $s(K)$, is implicitly defined by

$$Q(s(K)) = x[s(K)]\,(1-d)/2 = K\,. \tag{3.1}$$

In the early periods, price clears the existing capacity, $P(s)=1-K/x(s)$, while in the latter phase the firm has unutilized capacity and sets price

$$P(s) = (1+d)/2\,. \tag{3.2}$$

We can now characterize the vertically-integrated firm's optimal choice of capacity. The firm's profits are

$$\int_0^{s(K)} K[1-(K/x(s))-d]e^{-\rho s}ds + \int_{s(K)}^{\infty} \frac{x(s)(1-d)^2}{4} e^{-\rho s}ds - cK\,,$$

and differentiating this expression gives the solution, K^*:

$$\int_{0}^{s(K^*)} [1 - 2K^*/x(s) - d] e^{-\rho s} ds - c = 0 . \tag{3.3}$$

At time s in the early phase, the marginal return associated with an additional unit of capacity is $[1 - 2K^*/x(s) - d]$, the marginal revenue of a rental minus the incremental cost of a rental. The marginal return on an additional unit of capacity in the latter phase is zero because not all capacity is utilized. The vertically-integrated firm expands capacity to the point where the discounted marginal return on capacity equals the marginal cost, c.

The salient point is that a vertically-integrated firm intentionally under-utilizes its capacity and limits price reductions during low-demand times.[21] When the industry is vertically separated with competition downstream, there will be a tendency for the downstream firms to engage is "destructive competition," over-utilizing existing capacity and competing fiercely in price. The upstream firm needs to structure its contracts to (1) prevent fire sales during these low-demand times, and (2) encourage the right level of inventory holding.

Now suppose that the industry is vertically separated. What is the competitive outcome when the total industry capacity is $\tilde{K}$? In later periods not all capacity is used and the market price is driven down to the point where the downstream marginal revenue (after paying the royalty) is equal to the incremental cost of a sale,

$$(1 - r) P(s) = d \cdot \tag{3.4}$$

[21] This result holds when the demand variation over time is sufficiently large and a vertically integrated firm's optimal *ex post* rentals are not always equal to its capacity or inventory, which is implied by our assumption that *x(s)* approaches zero.

The quantity demanded during this phase is $Q(s) = x(s)\left(\frac{1-r-d}{1-r}\right)$. In early periods, however, all capacity is used and the market-clearing price is $1 - \widetilde{K} / x(s)$. The cutoff between these two regimes, $s(\widetilde{K})$, is implicitly defined by

$$Q(s(\widetilde{K})) = x(s(\widetilde{K}))\left(\frac{1-r-d}{1-r}\right) = \widetilde{K}. \tag{3.5}$$

We can now characterize the competitive industry's choice of capacity given contract *{t, r}*. In the early phase, the competitive downstream firms earn an *ex post* return or rent of $(1-r)[1-\widetilde{K} / x(s)] - d$ on each unit of capacity. In the later periods, not all capacity is used and there are no *ex post* rents.[22] The industry capacity will expand to the point where the downstream firms' discounted marginal return on a unit of capacity is equal to their marginal cost of capacity:

$$\int_0^{s(\widetilde{K})} \{(1-r)[1-(\widetilde{K} / x(s))] - d\} e^{-\rho s} ds - t = 0 . \tag{3.6}$$

First imagine that the monopolist sets the unit transfer price equal to marginal cost, $t = c$, and the revenue share equal to zero, $r = 0$. Two distortions would arise. First, comparing (3.2) and (3.4) shows us that during the later periods when demand is low the competitive market will set too low a price. It is not possible for the competitive market to commit itself not to use all its available capacity *ex post*. A contract with a revenue share or royalty $r^* = \frac{1-d}{1+d}$ solves the *ex post* pricing distortion and commits the competitive downstream market not to use all available capacity. Second, if we supposed that the two regimes have the same prices and cutoffs, then comparing (3.3) and (3.6) shows that under marginal cost pricing the competitive market would choose a capacity level that is too high. A transfer price $t^* = \left(\frac{d}{1+d}\right)c$ gets the competitive firms to choose K^*.

<u>Proposition 2</u>: If there is perfect competition downstream, the upstream monopolist will implement the vertically integrated outcome with a revenue-sharing contract $\left\{\left(\frac{d}{1+d}\right)c, \left(\frac{1-d}{1+d}\right)\right\}$.

Other vertical restraints also implement the vertical-integration outcome in this model. In a similar model, Deneckere, Marvel and Peck (1997) showed that minimum resale prices will prevent *ex post* destructive competition. However, revenue sharing is legal while resale price maintenance is not. Marvel and Peck (1995), Kandel (1996) and Padmanabhan and P'ng (1997) have examined the role of returns contracts (or buybacks). Each of these papers considers a model of inventory choice, pure resale, and uncertain (as opposed to declining) demand. Again, returns contracts are less effective when the retailers are purchasing capacity as opposed to inventory. The optimal return contract would specify a return price as a function of time and firms would instantaneously adjust their capacities over time. More generally, an optimal return contract might require a video retailer to return tapes on Monday when demand is low only to have them shipped back in time for the weekend. Given the transactions costs associated with these buyback

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[22] The cutoff between these two regimes is where $1-(\tilde{K}/x(s)) = d/(1-r)$.

schemes and the relative ease of tracking rentals directly, the physical return of videos has no advantage.[23]

4. Concluding Remarks

This paper has considered two models where an upstream firm with market power wants to encourage inventory holding and soften price competition among its downstream retailers when there is uncertain or variable demand. For each of these models we showed that revenue-sharing contracts, together with a linear input price, correct these distortions and implements the vertical-integration outcome.

The paper considers an upstream monopolist, but clearly the model could be generalized by considering differentiated duopolists selling to exclusive competing downstream firms. In this case revenue sharing would implement the duopoly outcome obtained when each vertical chain is integrated. A more realistic model is one where differentiated firms (movie studios) sell to common competing downstream firms (video rental chains), but this problem is complicated by the common agency problem and by the fact that inventories of the different upstream firm's products represent *ex post* substitutes for one another. Finally the second model could easily be generalized by allowing more realistic idiosyncratic demand uncertainty instead of, or in addition to, aggregate demand uncertainty.

The idea that revenue sharing can encourage inventory holding and soften downstream price competition applies to other industries as well, including supply

[23] When retailers are privately informed about demand, then resale price maintenance may be more attractive to the upstream monopolist than returns contracts or revenue sharing (see Butz, 1998).

contracts in manufacturing. For example, many of the suppliers of aircraft engine parts, who often have considerable market power, operate under revenue-sharing agreements with engine manufacturers, who compete fiercely for contracts with major carriers.[24] If the downstream demand for manufactured products is variable or stochastic, then it may be efficient for downstream firms to stockpile parts that will be readily available when an order comes in. If the supply contracts simply specified a marked-up linear price for the parts, then too little inventory would be held, delivery of the final products would be delayed, and economic value will be foregone. Revenue sharing, along with a low linear price, can more efficiently align the incentives in the vertical chain.

Vertical integration is clearly an alternative to the use of revenue-sharing contracts. However it is a solution that is not practical or feasible in the examples we consider. Video rental stores are outlets for multiple studios (each of whom has a monopoly on their films), and it is not possible for them all to vertically integrate forward. Economies of density create a strong incentive for downstream retailers to carry the videos of all movie studios. Perhaps more importantly, vertical integration would consolidate downstream firms and might lead to antitrust violations.

Although our analysis focussed on contracts with a particular form, there are contractual alternatives. For example, the models all considered royalty payments as *a percentage of revenues*. It is straightforward to show that analogous results exist for

[24] For example, Lucas Aerospace recently entered into a revenue-sharing contract with Rolls-Royce to supply engine and fuel control systems for the new generation of Trent Engines. "Team on Trent Engines," *Aviation Week and Space Technology*, January 19, 1998. Under the terms of the deal, Lucas will invest $122 million and receive 3-5% of the total revenues from the engines.

contracts with *a fixed price per unit of output*.[25] While other vertical restraints, such as resale price maintenance and returns contracts, may help to correct these distortions in some of the models we consider, revenue sharing has the advantage of being legal and in many cases administratively and logistically simpler than these alternatives.

[25] In the case of pure resale this is the typical returns contracts. However in a dynamic model a fixed payment per unit sold paid at the time of sale would be different from a fixed payment per unit not sold paid at the time of a return.

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