

# The iPhone Goes Downstream: Mandatory Universal Distribution\*

Larry S. Karp<sup>†</sup>      Jeffrey M. Perloff<sup>‡</sup>

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## Abstract

Apple's original decision to market iPhones using a single downstream vendor prompted calls for mandatory universal distribution (MUD), whereby all downstream vendors would sell the iPhone under the same contract terms. The upstream monopoly may want either one or more downstream vendors, and, in either case, consumer welfare may be higher with either one or more firms. If the income elasticity of demand for the new good is greater than the income elasticity of the existing generic good, the MUD requirements leads to a higher equilibrium price for both the new good and the generic, and therefore lowers consumer welfare.

*Keywords:* vertical restrictions, mandatory universal distribution, new product oligopoly

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<sup>†</sup>Department of Agricultural and Resource Economics, 207 Giannini Hall, University of California, Berkeley CA 94720 email:karp@berkeley.edu

<sup>‡</sup>Department of Agricultural and Resource Economics, 207 Giannini Hall, University of California, Berkeley CA 94720 email:jperloff@berkeley.edu

# 1 Introduction

Apple signed a contract in 2007 that granted one U.S. wireless phone provider, AT&T, the exclusive right to distribute its iPhone for five years.<sup>1</sup> Consumer organizations such as Consumers Union called on the government to require that the iPhone be available through many or all downstream providers. In 2009, a Senate antitrust panel held hearings and Senators listed steps that they wanted the FCC and the Department of Justice to take to make the downstream industry more competitive (Consumer Reports 2009). The issue of mandating universal distribution (MUD) has arisen in many markets (e.g., movies, video games, and other durables) in the past and will arise with new, disruptive inventions. A MUD requirement allows all distributors to carry the product on the same terms. One of the chief arguments by proponents of MUD appeals to the conventional wisdom that the equilibrium price falls when there are more firms in the market. It is, of course, well-known that if the upstream industry is competitive, then raising the number of Cournot oligopolistic downstream firms lowers the price to final consumers. However, this relation may not hold if the upstream provider is a monopoly that can adjust the wholesale price that it charges downstream firms depending on the number of vendors that carry its product. We identify conditions under which MUD helps or hurts consumers and society.

We assume that there is a vertical industry structure, with two types of upstream firms. A monopoly produces a new product (e.g., Apple's iPhone). A competitive industry produces a generic product. Downstream, a quantity-setting oligopoly sells the generic and some or all of the firms also sell the new product.

We use a two-stage model. In the first stage, an upstream monopoly that has a new product decides whether it wants one or more downstream vendors to distribute its product. The upstream firm charges a constant wholesale price, but charges each downstream firm a lump-sum fee for the right to carry its product (thereby allowing the monopoly to capture downstream profits). In the second stage, the downstream firms use a fixed-proportion production process: they resell the phones to final consumers. Both downstream firms sell a generic product. One or more of the downstream firms also sells the new product. The firms choose how many units of the new and the generic product they sell and a Cournot equilibrium results.

We focus on two issues that determine the outcome: the degree to which consumers are willing to substitute the new product for the generic product, and the size of the fixed cost to enable each downstream vendor to sell the new product. AT&T incurred substantial cost to

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<sup>1</sup>“Supporting Memorandum of Points and Authorities,” In Re Apple & AT&TM Anti-trust Litigation, U.S. District Court, Northern District of California, San Jose Division, Case no. C 07-5152 JW, September 12, 2008. Either this exclusivity contract, which should have lasted through 2012, had escape clauses or Apple renegotiated with AT&T. Apple signed contracts allowing AT&T's competitors Verizon and Sprint to start selling iPhones in 2011.

enable the iPhone to work on its network. The upstream firm may want to sell to only one downstream firm and consumers may be better off with either one or two (or more) vendors downstream. Similarly, the upstream firm may want to sell to two (or more) downstream firms and consumers may or may not be better off with one vendor. Which of the four possible outcomes occurs depends on the combination of fixed cost and degree of substitution.

We start by examining two extreme cases, where imposing MUD is undesirable: First, the new and the generic product are not substitutes and downstream firms are oligopolistic. Second, the downstream firms behave as price takers (and the goods may or may not be substitutes). We then turn to our main model in which the goods are substitutes and the downstream firms are oligopolistic. For simplicity, we assume that there are two downstream firms.

Many papers examine vertical relations and some consider substitution between products downstream. We are not aware of any paper that analyzes the MUD policy. Our model is similar to those of several literatures that show upstream firms can use vertical contracts (or vertical integration) to soften competition by raising rivals' costs (possibly through sabotage) or foreclosing entry strategically (Salop and Scheffman 1983, Aghion and Bolton 1987, Economides 1998, Ordober, Salop and Saloner 1990, Hart and Tirole 1990, Riordan 1998, Weisman 2001, White 2007, and Bustos and Galetovic 2008). In many of these articles, vertical foreclosure occurs because an upstream firm controls some "essential facility" or "bottleneck resource" that competing firms need access to at comparable prices to compete downstream. A key point in many of these papers is that firms can collectively earn only a single monopoly profit so that the upstream firm, by charging a monopoly price for access to the essential facility, can extract all of the monopoly rents without further harming consumers.

Our paper captures this same insight, though we focus on a model in which the upstream monopoly captures rents through a transfer payment as well as through per-unit charges. Some of the foreclosure literature examines government policies that forbid explicit foreclosure, which is similar to a MUD policy. However, our results differ from most of that literature because our upstream product competes with another product downstream.

Another literature on slotting allowances and other vertical restrictions (Shaffer 2005, and Innes and Hamilton 2006 and 2009) deals with a very different policy question but use models with similar vertical structures. Slotting allowances are fees that grocery chains receive from manufacturers to provide shelf-space for their goods. Established upstream firms may encourage the use of such fees to prevent entry by other upstream competitors. Our model is similar to many of these models in that it allows upstream and downstream firms to sign contracts in the first stage that affect the degree of competition in the final stage. These models differ from ours because they concentrate on the competition among oligopolistic upstream firms whereas we look at competition among oligopolistic downstream firms. Moreover, the direction of lump-

sum transfers in their models is the opposite of ours.

Although our models differ, some of our results resemble those of the strategic trade literature (Spencer and Brander 1983), where the upstream firm's actions allow a single downstream vendor to commit and gain a strategic advantage over its rival. One other literature that is similar in spirit to our paper concerns wholesale non-discrimination rules. MUD could be viewed as a particular non-discrimination rule that forbids setting the price to some downstream firms prohibitively high. Indeed, in an argument analogous to the current debate, Bork (1978) suggested that total welfare would increase if new markets are served if wholesale price discrimination is allowed. However, these papers look at a very different vertical model. Typically in these models, the upstream monopoly wants to discriminate because the downstream firms have different costs or serve markets with different demand elasticities (Schmalensee 1981, Varian 1985, Katz 1987, De-Graba 1990, Ireland 1992, Yoshida 2000, and Villas-Boas 2009). We abstract from those considerations by assuming that all downstream firms are identical and all sell in the same market. This simplification allows us to focus attention on the strategic reasons for selling to one or more downstream firms, reasons not discussed in detail in the discrimination literature.

In short, while there are many papers that examine vertical relations, some that consider substitution between products downstream, and a few that examine contracting issues and lump-sum transfers, we are unaware of any paper that cover all these features, and no other paper examines the MUD policy question.

## 2 Extreme cases

We start by considering two extreme cases where a MUD restriction does not affect consumer welfare but lowers industry profit and hence social welfare. In the first extreme case, the upstream monopoly sells a good that is not a substitute for existing goods. We assume that the downstream firms incur no additional cost of selling the good. There are a limited number of potential downstream firms,  $N$ . When more than one firm sells the new good, the outcome is a Cournot equilibrium.

If the upstream monopoly's only instrument is its wholesale price then it has the traditional double marginalization problem where the monopoly marks up its wholesale price over its marginal cost of production, and the downstream vendor or vendors add a second markup to the wholesale price. The monopoly can avoid the double marginalization problem by vertically integrating downstream. Alternatively, it can quasi-vertically integrate if it has two instruments. For example, it can use a two-part tariff where it charges a vendor  $T$  for the right to carry its product and a constant wholesale unit price.

Because the monopoly can use  $T$  to capture a vendor's profit, the monopoly wants its vendor

to maximize this profit. If the monopoly sells to only one firm, it sets its wholesale price equal to its production cost so that the vendor charges the same price as would an integrated monopoly. If the monopoly sells to  $N$  downstream firms, it sets its wholesale price so that the resulting downstream price is the same as that of the integrated monopoly. The upstream monopoly captures all downstream profits by setting  $T$  appropriately.

Because the upstream monopoly can control the downstream price with its wholesale price regardless of the number of downstream firms, it is indifferent as to the number of vendors if there is no fixed cost (e.g., to enable a new phone to work on a network),  $F$ , associated with each vendor carrying its product. Given a positive fixed cost, it does not matter whether the fixed cost is paid by the upstream or downstream firm, as the upstream firm captures downstream profit and hence ultimately bears this cost. Consequently, if  $F > 0$ , the upstream monopoly wants to sell to only one downstream vendor. If a MUD requirement forces the upstream monopoly to sell to  $N$  downstream firms, the retail price and consumer welfare do not change, but the upstream monopoly's profit falls by  $(N - 1)F$ , and hence social welfare would drop by the same amount.

Alternatively, suppose that the MUD requirement requires that the monopoly offer the same contract terms to all potential firms. The monopoly will offer the same fixed fee and marginal cost pricing as when it deals with a single firm and only one firm accepts the contract in equilibrium. For example, the monopoly could offer the contract first to one firm, which would accept, and then offer the same contract to other firms, which would reject the offer. With this definition, the MUD requirement does not change welfare, because there is still a single downstream vendor. Thus, with this alternative definition, MUD requirement has no bite because the monopoly can offer contracts so that in equilibrium only one firm distributes its product. Therefore, in the rest of the paper, we assume that the MUD requirement forces the monopoly to sell its product through two vendors.

In the second extreme case, the downstream firms price competitively. If the new and the generic goods are not substitutes and there is no fixed cost, then the upstream firm would set its wholesale price equal to the integrated monopoly price because the downstream firms do not add a markup. This result is the classic one that an upstream monopoly is indifferent about vertically integrating given fixed-proportions production, because the upstream monopoly can control the downstream price without integrating. With a fixed cost, the monopoly would again want only one downstream firm, and consumers are indifferent about the number of downstream vendors.

If the new and the generic products are substitutes, an integrated monopoly would act like a monopoly with respect to its residual demand curve given the competitive supply curve of the generic product. That is, the integrated firm acts like a dominant firm facing a competi-

tive fringe. By the same reasoning as above, the upstream monopoly can quasi-integrate by setting its wholesale price so that the downstream price equals the integrated-monopoly price. If  $F = 0$ , the upstream monopoly is willing to sell to all firms at an appropriate wholesale price. However if  $F > 0$ , it uses only one downstream vendor. Again, if  $F > 0$  and the MUD requirement is imposed so that the upstream firm must use more than one downstream vendor, its profit falls as does social welfare, and consumers receive no benefit. Thus, in either of these extreme cases, the MUD requirement is harmful.

### 3 Substitutes

We now consider a market in which the goods are substitutes and there are only two downstream firms. We continue to assume that the downstream firms use a fixed-proportion production function and have no additional marginal cost. The monopoly's wholesale price is the sum of its cost of production plus a constant markup,  $m$ . A competitive industry with constant average costs produces the generic good, so that the downstream firms buy the generic at its cost of production.

The downstream duopoly firms,  $i = 1$  and  $2$ , are quantity setters. The quantity  $q_{ji}$  is the amount that Firm  $i$  sells of product  $j$ , where  $j = g$  is the generic good and  $j = n$  is the new product. For notational simplicity and to avoid the need to keep track of upstream marginal production costs, we express the price  $p_g$  for the generic and the price  $p_n$  for the new good net of their constant upstream marginal production costs.

There are four possible outcomes. The upstream monopoly may want either one or two downstream vendors, and, in either case, consumer welfare may be higher with either one or two firms. We show that even with a linear model, all four of these outcomes are possible.

#### 3.1 Two-stage game

The firms play a two-stage game. In the first stage, the monopoly offers downstream firms contingent contracts. The firms simultaneously decide whether to accept the contract offered to them. The outcome of this stage determines  $k \in \{1, 2\}$ , the number of downstream firms that sell the product;  $m$ , the amount by which the wholesale price exceeds the upstream monopoly's marginal cost of production; and  $T$ , the lump-sum transfer from the vendor to the upstream monopoly. In the second stage, the downstream firms play a Cournot game in which they decide how many units of the new and generic products to sell. If both firms reject their contract, neither sells the new good. They then play a Cournot game in which they sell only the generic and receive equilibrium profits  $\pi^e$ .

In the absence of a MUD requirement, the monopoly can offer the firms asymmetric contingent contracts that will result in an equilibrium in which only a single firm sells its product. For example, it can offer Firm 2 terms  $\tilde{m}$  and  $\tilde{T}$  conditional on Firm 1 rejecting its contract and Firm 2 accepting its contract. Firm 2's terms are  $m \rightarrow \infty, T = 0$  conditional on both firms accepting their contracts. For the situation in which Firm 2 accepts and Firm 1 rejects the contract, the monopoly can choose  $\tilde{m}$  and  $\tilde{T}$  to ensure that Firm 2's profit exceeds  $\pi^e$  and Firm 1 has a very low profit.<sup>2</sup> Firm 2's strictly dominant strategy is to accept its contract. It has nothing to lose by accepting: if Firm 1 also accepts, Firm 2 pays no transfer and buys nothing from the monopoly. However, if Firm 1 rejects, then Firm 2 does strictly better by accepting. Recognizing that Firm 2 will accept its contract, Firm 1's optimal strategy is to accept its contract, provided that its payoff is above the equilibrium level when Firm 1 rejects and Firm 2 accepts the contract.

Alternatively, the monopoly can induce an equilibrium in which both firms sell its product by offering symmetric contingent contracts. Under a MUD restriction, it must offer symmetric contracts that induce both firms to sell its product. Appendix A.1 presents a normal-form game that illustrates how the monopoly can use contingent contracts to extract rent from downstream firms. The contract offers place the downstream firms in a prisoner's dilemma game. If Firm  $i$  accepts and Firm  $j$  rejects, Firm  $j$ 's profit is small and Firm  $i$ 's profit is large. If both firms accept, their payoffs are larger than the equilibrium profits of a firm that rejects when the other firm accepts. By choosing the contract terms in such a way that the profits are sufficiently large for the firm that accepts when the other firm rejects, the monopoly can ensure that acceptance is a dominant strategy.

The first stage determines the number of downstream vendors,  $k$ , and the equilibrium values of the contract terms,  $m$  and  $T$ , which depend on  $k$ :  $m^*(k)$  and  $T^*(k)$ . Substituting these values into the duopoly profit functions, we write the equilibrium profit functions as  $\pi_i^*(k)$ . When we want to denote downstream profits evaluated at a general (possibly non-equilibrium) value of  $m$ , we write  $\pi_i^*(k, m)$ . If Firm  $i$  is a vendor, its profit function is  $\pi_i = p_g q_{gi} + (p_n - m) q_{ni} - T$ , the sum of the profits from selling generics and from selling the new good, minus the transfer payment. We adopt the convention that if there is a single vendor, it is Firm 1. If Firm  $i$  sells only the generic good, its profit function is  $\pi_i = p_g q_{gi}$ .

The monopoly's ability to credibly commit to contingent contracts gives it a great deal of power to make implicit threats or promises (of very low or very high downstream profits) that are not realized in equilibrium. For example, absent any restriction on the monopoly's ability to make contingent contracts, in equilibrium its vendor's profits may be lower than those of the

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<sup>2</sup>Given that the monopoly sets  $\tilde{m}$  to a low, possibly negative, level, Firm 2 sells the new product aggressively, harming Firm 1. The choice of  $\tilde{T}$  ensures that Firm 2's equilibrium profit exceeds  $\pi^e$ .

non-vendor. We regard this outcome as implausible. To eliminate it, we restrict the monopoly's power by means of the following two assumptions:

**Assumption 1** *In the event that the monopoly has a single vendor, the vendor's profit exceeds its rival's profit by at least  $\varepsilon$ . We consider the limiting case where  $\varepsilon \rightarrow 0$ .*

**Assumption 2** *When both firms are vendors, their profits are no less than the level when only one is a vendor.*

Assumption 1 induces an *endogenous* equilibrium level of profit,  $\pi_1^*(1) = \pi_2^*(1)$ . This profit level, together with Assumption 2, determines the equilibrium profit level when the monopoly sells to both firms. The two assumptions imply that

$$\pi_1^*(1) = \pi_2^*(1) = \pi_1^*(2) = \pi_2^*(2). \quad (1)$$

We compare the one-vendor and two-vendors equilibria. We solve the upstream monopoly's problem by working backwards. First, we determine the Cournot equilibrium sales rules as functions of  $m$  when the monopoly sells to only Firm 1,  $q_{ji}^*(1, m)$ . Then we solve the upstream monopoly's problem when it sells to a single firm:

$$\Pi^*(1; F) = \max_{m, T} [mq_{n1}^*(1, m) + T - F] \text{ subject to } \pi_1^*(1, m, T) \geq \pi_2^*(1, m). \quad (2)$$

The constraint in this problem corresponds to Assumption 1. The monopoly's solution to this problem produces the equilibrium values  $m^*(1)$ ,  $T^*(1)$ ,  $\pi_i^*(1)$ , and  $\Pi^*(1; F)$ .

Using the constraint in Equation 2 and the definition of downstream profits to eliminate  $T$ , we rewrite the monopoly's maximization problem as

$$\Pi^*(1; F) = \max_m \underline{p_g q_{g1}^*(1, m) + p_n q_{n1}^*(1, m)} - F - \pi_2^*(1, m). \quad (3)$$

In a Stackelberg equilibrium, the leader maximizes its profit subject to the best-response function of the follower. In the usual Stackelberg setting, both leader and follower sell a single product. In our setting, Firm 1 might sell both the new and the generic product, while Firm 2 sells only the generic product. However, we use the terms "Stackelberg leader and follower" in the standard way: the leader maximizes its total profit, subject to the follower's best-response function.

Equation 3 illuminates the relation between the equilibrium in our problem and the equilibrium in which a single vendor of the new product behaves as a Stackelberg leader in the game in which both firms sell the generic and only the leader sells the new product. The downstream Stackelberg leader's profit is the underlined term in Equation 3: the profit of the single vendor,



exclusive of the markup and the transfer. The Stackelberg leader maximizes this profit. However, the upstream monopoly wants to maximize this term minus the profit of the non-vendor, because the monopoly can use the transfer to capture rents equal to the difference in the downstream firms' profits. The monopoly benefits not only by increasing its vendor's pre-transfer profit, but also by decreasing the non-vendor's profit.

The level of  $m$  that induces the single-vendor to act like a Stackelberg leader (i.e., that maximizes the underlined term in Equation 3) satisfies the necessary condition

$$\frac{d [p_g q_{g1}^* (1, m) + p_n q_{n1}^* (1, m)]}{dm} = 0. \quad (4)$$

The level of  $m$  that the monopoly chooses to solve the problem in Equation 3, satisfies

$$\frac{d [p_g q_{g1}^* (1, m) + p_n q_{n1}^* (1, m)]}{dm} - \frac{d \pi_2^* (1, m)}{dm} = 0. \quad (5)$$

An increase in  $m$  causes Firm 1 to reduce sales of the new product, thereby increasing Firm 2's profit, so  $\frac{d \pi_2^* (1, m)}{dm} > 0$ . Given this result and the assumed concavity of the monopoly's maximand, the monopoly's optimal choice of  $m$  is strictly less than the level of  $m$  that would induce its agent to behave as a single-vendor Stackelberg leader. As a consequence, the single vendor in this equilibrium chooses higher new product sales than would a single-vendor Stackelberg leader. Consequently, aggregate downstream profits, net of the markup and the transfer, are lower here than in the single vendor Stackelberg equilibrium.

To solve the problem when the monopoly sells to both firms, we obtain the symmetric Cournot equilibrium sales rules as functions of  $m$ ,  $q_j^* (2, m)$ . Here, we drop the firm index because the equilibrium is symmetric. We then solve the monopoly's problem

$$\Pi^* (2; F) = \max_{m, T} 2 [m q_n^* (2, m) + T - F] \text{ subject to } \pi_i^* (2, m, T) \geq \pi_2^* (1). \quad (6)$$

The constraint in this problem arises from Assumption 2, where  $\pi_2^* (1)$  is the value of a downstream firm's profit if the monopoly sells to a single firm: the solution to the problem in Equation 3. This term affects the value of the monopoly's payoff (because it affects the transfer), but it has no effect on the optimal level of the markup when the monopoly sells to two firms.

Using the definition of profits and the constraint in Equation 6, we rewrite the monopoly's maximization problem when it uses two vendors as

$$\Pi^* (2; F) = \max_m \underline{2 [p_g q_g^* (2, m) + p_n q_n^* (2, m)]} - 2 (\pi_2^* (1) + F). \quad (7)$$

The underlined term in Equation 7 is aggregate downstream profit before payment of the markup and the transfer. Because  $\pi_2^* (1)$  is a constant in this problem, maximization of the right side of Equation 7 is equivalent to maximizing the underlined term in that equation. Thus,

an upstream monopoly that uses two vendors chooses the markup to maximize downstream profits, exclusive of the markup and transfer.

In summary, we have

**Remark 1** *The monopoly that sells to one firm captures the profit of only its vendor and chooses a markup such that its vendor's profit (before payment of the transfer and markup) is less than that of the Stackelberg leader's profit in the single-vendor Stackelberg equilibrium. The monopoly that sells to two firms chooses a markup that maximizes the sum of downstream profits (before payment of the transfer and the markup).*

If only the generic were sold, consumer welfare would be higher in a Stackelberg equilibrium than in a Cournot equilibrium, and consumer welfare would be even higher if aggregate output exceeds the level in the Stackelberg equilibrium with one vendor. This analogy to non-differentiated goods suggests that consumers may be better off when the monopoly sells to a single vendor. However, the analogy is not exact because the goods are differentiated. Increasing the output of one good while decreasing the output of the other complicates the welfare comparison.

Downstream firms have market power in the downstream market. However, Assumptions 1 and 2 imply that they have no market power relative to the monopoly. Section 3.5.1 considers an alternative model that limits the monopoly's ability to extract rent from downstream firms, thus increasing downstream power vis a vis the monopoly.

### 3.2 Linear model assumptions

We now assume that the inverse demand functions for both the new and the generic product are linear:

$$\begin{aligned} p_g &= a - b(q_{g1} + q_{g2}) - c(q_{n1} + q_{n2}), \\ p_n &= A - B(q_{n1} + q_{n2}) - C(q_{g1} + q_{g2}). \end{aligned} \tag{8}$$

The intercepts  $a$  and  $A$  equal the intercept of the inverse demand curve minus the constant marginal production cost. All parameters are non-negative. Because these linear demand equations lead to closed-form expressions for the equilibrium sales rules, we can solve for the equilibrium levels of  $m^*(1)$  and  $m^*(2)$  and then compare the price levels and consumer welfare in the two scenarios.<sup>3</sup>

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<sup>3</sup>Moner-Colonques, Sempere-Monerris, and Urbano (2004) examine a market in which two upstream firms decide whether to sell their products through one or both of the downstream vendors. Their model allows the upstream firms to charge only a per unit price, whereas our upstream firm also uses a transfer. In addition, we allow the cross-price coefficients  $c$  and  $C$  to differ. The difference in these coefficients is key to our results.

The model has seven parameters,  $a$ ,  $A$ ,  $b$ ,  $B$ ,  $c$ ,  $C$ , and  $F$ . By choosing the units of the quantities, we can choose, without loss of generality, the own slopes of the inverse demand functions to be equal. Hereafter we set  $B = b$ . We also restrict  $A = a$ , and refer to the model with this restriction as “almost symmetric”; the magnitude of  $a$  is a scaling parameter, and does not affect our results. (Section 3.5.2 discusses the model without the restriction  $A = a$ .) The inverse demand equations in the almost symmetric model are

$$\begin{aligned} p_g &= a - b(q_{g1} + q_{g2}) - c(q_{n1} + q_{n2}), \\ p_n &= a - b(q_{n1} + q_{n2}) - C(q_{g1} + q_{g2}). \end{aligned} \quad (9)$$

That is, the intercepts and own-quantity slopes of the two products are identical. However, the cross-quantity effects, the degree to which one good substitutes for the other, differ. We now concentrate on the role of the three parameters,  $c$ ,  $C$ , and  $F$ . The almost symmetric model allows for all four possible outcomes, where the monopoly wants to sell to one firm or two firms, and monopoly and consumer interests are aligned or opposed.

We invert Equations 9 to write the demand system as

$$\begin{pmatrix} \mathbf{q}_g \\ \mathbf{q}_n \end{pmatrix} = \begin{pmatrix} \frac{ba-ac}{b^2-cC} \\ \frac{ab-aC}{b^2-cC} \end{pmatrix} - \begin{bmatrix} \frac{b}{b^2-cC} & -\frac{c}{b^2-cC} \\ -\frac{C}{b^2-cC} & \frac{b}{b^2-cC} \end{bmatrix} \begin{pmatrix} p_g \\ p_n \end{pmatrix}. \quad (10)$$

where aggregate quantities,  $\mathbf{q}_j = q_{j1} + q_{j2}$ , are functions of prices. Because the two goods are substitutes, we want the aggregate quantity demanded of a good to decrease as its own-price increases and rise with respect to the other price. In addition, we require that the aggregate demand for both goods be positive if both prices (which are net of their production costs) are zero:  $p_g = p_n = 0$ . These two conditions imply the parametric restrictions that the own-quantity parameter is greater than either of the other-quantity parameters:

$$b > c, \quad b > C. \quad (11)$$

An increase in the own-quantity has a larger effect on price than a comparable increase of the other-quantity.

These linear demand functions are approximations to a more general system of demand functions.<sup>4</sup> The relative magnitude of  $c$  and  $C$  plays a major role in the analysis. We use the indirect utility function to provide an economic interpretation of the sign of  $c - C$ . Denoting  $\mathbf{q}_j^{\text{Hicksian}}$  as the Hicksian demand and  $\mathbf{q}_j$  as the Marshallian demand (as above), the Slutsky equation is

$$\frac{\partial \mathbf{q}_j}{\partial p_i} = \frac{\partial \mathbf{q}_j^{\text{Hicksian}}}{\partial p_i} - \mathbf{q}_i \frac{\partial \mathbf{q}_j}{\partial y}.$$

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<sup>4</sup>The quadratic utility function produces linear demand functions. However, symmetry of the cross partials of the Hicksian demand functions requires  $c = C$  (Singh and Vives, 1984).

We obtain the partial derivatives,  $\frac{\partial \mathbf{q}_j}{\partial p_i}$ , from Equations 10. We then use the symmetry relation

$$\frac{\partial \mathbf{q}_g^{\text{Hicksian}}}{\partial p_n} = \frac{\partial \mathbf{q}_n^{\text{Hicksian}}}{\partial p_g},$$

and the Slutsky equation to show that the parameters of the demand equation satisfy

$$\frac{\partial \mathbf{q}_g}{\partial p_n} - \frac{\partial \mathbf{q}_n}{\partial p_g} = \frac{c - C}{b^2 - cC} = \frac{\mathbf{q}_g \mathbf{q}_n}{y} (\eta_n - \eta_g), \quad (12)$$

where  $\eta_j$  is the income elasticity of demand for commodity  $j$ . Inequalities 11 imply  $b^2 - cC > 0$ . This inequality and Equation 12 imply

**Remark 2** *The sign of  $c - C$  is the same as that of the difference between the income elasticities,  $\eta_n - \eta_g$ . If consumers view a new product as more of a luxury than a generic product so that the income elasticity of the new product is greater than that of the generic, then  $c > C$ .*

### 3.3 Equilibria

To compare the equilibrium with linear inverse demand functions where the monopoly sells to two firms to the equilibrium where it sells to only one firm, we first determine the downstream firms' Cournot equilibrium quantities given  $m$ . We then use that information to solve the upstream monopoly's profit maximizing problem to determine  $m$ .

Using the inverse demand Equations 8, the profit of downstream Firm  $i$ , exclusive of any transfer is

$$\pi_i = [a - b\mathbf{q}_g - c\mathbf{q}_n]q_{gi} + [a - b\mathbf{q}_n - C\mathbf{q}_g - m]q_{ni}. \quad (13)$$

Because Firm 1 always sells both goods, its first-order conditions are

$$\frac{\partial \pi_1}{\partial q_{g1}} = a - 2bq_{g1} - bq_{g2} - c\mathbf{q}_n - Cq_{n1} = 0, \quad (14)$$

$$\frac{\partial \pi_1}{\partial q_{n1}} = a - 2bq_{n1} - bq_{n2} - C\mathbf{q}_g - cq_{g1} = 0. \quad (15)$$

If Firm 2 does not sell the new product,  $q_{n2} = 0$  in Equation 15, and hence  $\mathbf{q}_n = q_{n1}$  in Equation 14.

If Firm 2 sells both goods, then its first-order conditions are the same as Equations 14 and 15 with the subscripts 1 and 2 reversed. However, if Firm 2 sells only the generic good, it has a single first-order condition for the generic good:

$$\frac{\partial \pi_2}{\partial q_{g2}} = a - 2bq_{g2} - bq_{g1} - cq_{n1} = 0. \quad (16)$$

If the monopoly sells to both firms, there are four first-order conditions: Equations 14 and 15 and the same pair of equations with the subscripts 1 and 2 reversed. However, given symmetry across firms, these four equations collapse into two first-order conditions, where the quantity for each firm is replaced by  $q_j/2$ . When the monopoly sells to both firms, it is indifferent about the division of sales between the two firms. It has one instrument,  $m$ , to affect two targets: aggregate new product and aggregate generic quantities,  $q_g$  and  $q_n$ .

In contrast, if the monopoly sells to only Firm 1, then there are three relevant first-order conditions, Equations 14, 15, and 16. Thus when the monopoly sells to a single firm, it use the same single instrument to control three targets: new product sales by Firm 1, aggregate generic sales, and Firm 1's share of generic sales (or equivalently,  $q_{n1}$ ,  $q_{g1}$ , and  $q_{g2}$ ). For a given level of aggregate generic sales, the monopoly prefers its agent, Firm 1, to have a larger share so as to increase Firm 1's pre-transfer profit, which the monopoly captures through the transfer  $T$ .

When the monopoly sells to only Firm 1, we can solve the first-order conditions, Equations 14 – 16, to obtain the duopoly sales as functions of  $m$ . Differentiating these expressions with respect to  $m$  and using the parameter restrictions in Equation 11, we obtain the comparative statics results:

$$\frac{dq_{n1}}{dm} < 0 < \frac{dq_{g1}}{dm}. \quad (17)$$

(This inequality also holds when the monopoly sells to two firms.) An increase in  $m$  reduces Firm 1's marginal profit from each new product sale, causing it to reduce sales in that market. That reduction in new product sales causes Firm 1's marginal revenue curve in the generic market to shift out, increasing sales in that market. The equilibrium level of Firm 2 generic sales (when the monopoly sells only to Firm 1) is

$$q_{g2} = -\frac{(C - c)}{(6b^2 - 4cC - C^2 - c^2)}m + \text{a constant}. \quad (18)$$

Consequently,

$$\frac{dq_{g2}}{dm} \left\{ \begin{array}{l} < \\ = \\ > \end{array} \right\} 0 \text{ for } \left\{ \begin{array}{l} C > c \\ C = c \\ C < c \end{array} \right\}. \quad (19)$$

The value of  $m$  has only an indirect effect on Firm 2's profit due to the changes in Firm 1's sales, described in Inequality 17. The changes in Firm 1's sales of the two goods, resulting from a change in  $m$ , have counteracting effects on Firm 2's marginal revenue curve. As  $m$  increases, Firm 1 sells fewer units of the new good, which helps Firm 2, but more units of the generic product, which hurts Firm 2. Remark 2 suggests that it is reasonable to expect that  $C < c$ , so  $dq_{g2}/dm > 0$ .

An increase in  $m$  affects only the term  $bq_{g1} + cq_{n1}$  within Firm 2's marginal revenue, Equation 16. Straightforward calculations show that

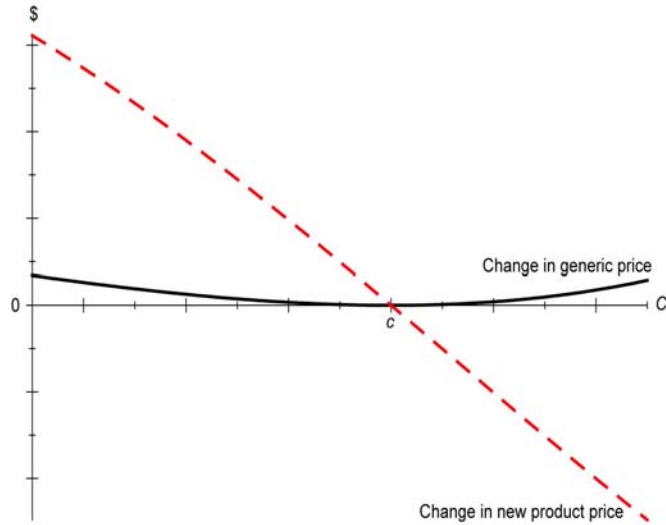


Figure 1: Changes in prices from adding a second vendor.

$$\frac{d(bq_{g1} + cq_{n1})}{dm} = 2b \frac{C - c}{6b^2 - 4Cc - C^2 - c^2}.$$

The denominator of the right-hand-side term is positive by Inequalities 11. Thus, an increase in  $m$  shifts up Firm 2's marginal revenue curve if and only if  $C < c$ , which makes the numerator of the right-hand-side term negative. If Firm 2's marginal revenue shifts up, it chooses to sell more units of the generic good.

If  $C = c$ , then a change in  $m$  does not affect the marginal revenue curve, so  $q_{g2}$  is a constant. Here, the monopoly has two targets – the same number as when the monopoly sells to both firms. However, if  $C \neq c$ , when the upstream monopoly sells to a single firm, it realizes that its choice of  $m$  affects the equilibrium choice of Firm 2's generic sales; it then has three targets compared to two when it sells to both firms. These comparative statics results help to explain the relation between parameter values and the manner in which the choice of one vendor or two vendors affects prices.

The ability to obtain explicit formulae for the equilibrium decision rules enables us to compare the new product and the generic prices in the two regimes (Appendix A.2). The following summarizes the comparison.

**Remark 3** *If the upstream monopoly sells to two firms rather than one, the generic price is higher for  $c \neq C$  and is unchanged for  $c = C$ , while the new product price is higher for  $C < c$ , equal for  $c = C$ , and smaller for  $C > c$ .*

Although we obtain all our main results analytically, we illustrate the more important ones

using simulations.<sup>5</sup> Figure 1 shows how the generic and new product prices change, as a function of  $C$ , if the upstream monopoly adds a second vendor (where we fix  $c$ ,  $F > 0$ , and the other parameters). When two firms sell the new product, each firm internalizes some portion of the effect of generic sales on the new-product price. As a result, the generic price increases (when two rather than one firm sells the new product) for  $C \neq c$ . Having two firms sell the new product increases the price of the new product for  $C < c$ , and decreases the price for  $C > c$ . By Remark 2, if the income elasticity for the new good is greater than that of the generic, then  $c > C$ , so the prices of both goods rise as the number of downstream vendors increases from one to two.

### 3.4 Welfare

By Equation 1, the downstream firms' profits are the same regardless of whether the monopoly uses one vendor or two. Therefore, the total welfare effect of a MUD requirement depends on only its effects on consumer welfare and monopoly profit. We consider first the monopoly's profit and then consumer welfare.

If  $F = 0$ , the monopoly strictly prefers to sell to two vendors for  $c \neq C$  and is indifferent between selling to one vendor or two vendors if  $c = C$ . For  $F > 0$  the monopoly prefers to sell to a single vendor if and only if  $|c - C|$  is small. To demonstrate this claim, we examine the two cases, where the upstream monopoly sells to one firm and where it sells to two firms. In both cases we use the firms' necessary conditions to write their sales as functions of  $m$ . For each of the two cases, we substitute these sales rules into the monopoly's profit functions, given by Equations 2 and 6. Each of these profit functions is quadratic in  $m$ . We maximize each function with respect to  $m$  to obtain the equilibrium monopoly profits in the two cases,  $\Pi^*(1; 0)$  and  $\Pi^*(2; 0)$ . Subtracting the former from the latter, we find that

$$\Pi^*(2; 0) - \Pi^*(1; 0) = \frac{[a(b + C)(c - C)(c - 2b + C)]^2}{9b(Cc - b^2)^2(9b^2 - 2c^2 - 2C^2 - 5Cc)} - F. \quad (20)$$

The denominator of the right side of this equation is positive by Inequality 11, Equation 20 implies

**Remark 4** *When  $F = 0$ , the difference in profits is positive for  $c \neq C$  and zero for  $c = C$ . For  $F > 0$ ,  $\Pi^*(2; 0) - \Pi^*(1; 0) < 0$  for small  $|c - C|$ . A larger  $F$  decreases  $\Pi^*(2; 0) - \Pi^*(1; 0) - F$  and therefore increases the measure of parameter space  $(c, C, b)$  for which  $\Pi^*(2; 0) -$*

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<sup>5</sup>Given our earlier assumptions, we have three free parameters,  $c, C$ , and  $F$ , but only  $c$  and  $C$  have a direct effect on the equilibrium quantities for a given number of downstream vendors. We set  $a = 10$  and  $b = 10/9$  in all our simulations. Given Inequalities 11, these parameter choices imply that  $c$  and  $C$  must each be less than  $10/9$ . For specificity, we set  $c = 0.5$  and  $F = 0.2$ , and examine how the results vary with  $C$ .

$\Pi^*(1;0) - F < 0$ . In this sense, the larger is  $F$ , the “more likely” is it that the upstream monopoly prefers to sell to a single firm. All else the same, using two vendors rather than one reduces the monopoly’s profit by  $F$ .

We can use Remark 3 to establish

**Remark 5** (i) For  $C < c$  consumers prefer the monopoly to use a single vendor. (ii) For  $C > c$  and  $C - c$  sufficiently small, consumer welfare is higher when the monopoly sells to two vendors.

Part (i) follows from the fact that for  $C < c$ , consumers face higher prices for both products when the monopoly uses two vendors rather than a single vendor. For  $C > c$ , adding a second vendor increases the generic price and decreases the new product price, so that the effect on consumer welfare of the second vendor is ambiguous in general. Appendix A.4 provides a formal statement and proof of Remark 5.ii, but the intuition is clear from Figure 1. The generic price under two vendors minus the generic price with one vendor is minimized at  $C = c$ , where the price difference is zero. Therefore, in the neighborhood of  $C = c$ , this price difference is of second order in  $C - c$  (i.e., the first-order Taylor expansion, with respect to  $C$ , of the price difference, evaluated at  $C = c$  is zero).<sup>6</sup> Consequently, the loss in consumer welfare arising from the higher generic price (when the monopoly moves from one vendor to two vendors) is a second-order effect. However, as is evident from Figure 1, adding a second vendor creates a first-order decrease in the new product price, and therefore creates a first-order welfare gain for  $C > c$ . Therefore, the first-order approximation of the change in consumer welfare (evaluated at  $C = c$ ) from the addition of a second vendor is positive.

Figure 2 illustrates the effect on the monopoly’s profit and consumer welfare of adding a second vendor, given that  $F > 0$ .<sup>7</sup> The dashed curve is the change in a representative consumer’s utility from having two rather than one vendor of the new product. Remark 5 implies that this curve crosses the axis at  $C = c$  from below. This curve is independent of  $F$ . The solid curve is the change in the monopoly’s profit from having two downstream vendors rather than one. It illustrates Remark 4, which states that the change in monopoly profit from selling to two firms rather than to one is negative in the neighborhood of  $C = c$  for  $F > 0$ , but is positive where  $|c - C|$  is large relative to  $F$ .

Figure 2 helps to establish

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<sup>6</sup>This claim can be verified immediately using the equation for the difference in generic prices, Equation 21 in the Appendix. Similarly, the claim regarding the difference in new product price can be verified by using Equation 22.

<sup>7</sup>We use the same parameters as above to simulate this figure. This figure uses the *change in consumer surplus* only to illustrate the change in consumer welfare. Neither our heuristic argument in the text nor the formal statement and proof in Appendix A.4 concerning the change in consumer welfare involve consumer surplus.



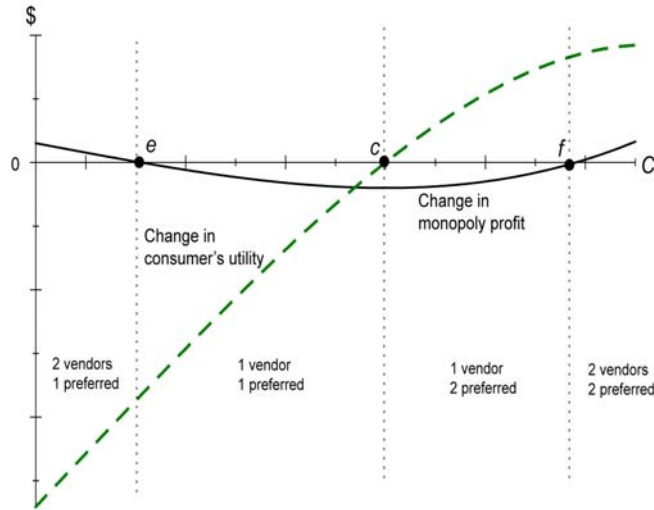


Figure 2: Change in Monopoly Profit and Consumer's Utility from Adding a Second Vendor

**Remark 6** Given parameters values  $a, b, c$ , and for  $F > 0$ , there is a value  $e < c$  such that (i) for  $C < e$  the monopoly prefers to sell to two firms, but consumers are better off when the monopoly sells to a single firm; (ii) for  $e < C < c$  both consumers and the monopoly are better off when the monopoly sells to a single firm; (iii) for  $C > c$  with  $C - c$  sufficiently small, consumers are better off when the monopoly sells to two firms, but the monopoly prefers to sell to a single firm. In addition, (iv) for sufficiently small  $F$  there is a value  $f > c$  such that for  $C > f$  with  $C - f$  small, the monopoly prefers to sell to two firms and consumers also prefer that the monopoly sells to two firms.<sup>8</sup>

Claims (i) – (iii) follow immediately from inspection of Figure 2 and from Remarks 4 and 5. To demonstrate (iv), we denote  $\Gamma$  as the closure of the set of  $C > c$  at which consumers prefer that the monopoly use two vendors. From Remark 5,  $\Gamma$  has positive measure. Because we can make  $f$  arbitrarily close to  $c$  by choosing  $F > 0$  but small, we can insure that  $f \in \Gamma$  for small  $F > 0$ . Such a value of  $f$  corresponds to the value shown in Figure 2.

We have seen that adding a second vendor increases the new-product price when  $C < c$  and decreases that price when  $C > c$ . At a given markup, the increased competition arising from the presence of a second vendor tends to decrease the new-product price. However, the monopoly adjusts the markup when it adds a second vendor.

The following summarizes the relation between the parameter  $C$  and the equilibrium markup:

<sup>8</sup>We do *not* assert that for all  $C > f$  consumers prefer two vendors. Claim (iv) is limited to the neighborhood of  $f$  for small  $F$ .

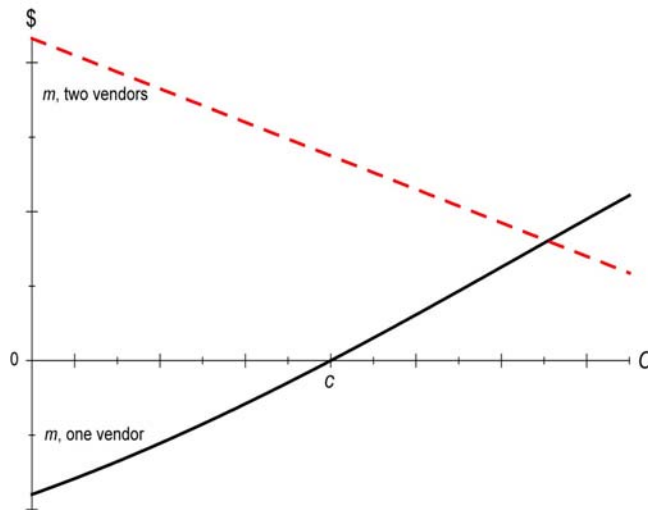


Figure 3: The upstream monopoly's markup with one or two vendors.

**Remark 7** (i) If the monopoly sells to a single vendor it subsidizes its vendor ( $m < 0$ ) if  $C < c$  and uses a positive markup if  $C > c$ . The markup is an increasing function of  $C$ . (ii) If the monopoly sells to two vendors, it uses a positive markup, a decreasing function of  $C$ .

Figure 3 illustrates this Remark; Appendix A.3 confirms it. The monopoly subsidizes a single vendor ( $m < 0$ ) if  $C < c$ , where generic sales have a relatively small effect on new-product price. The monopoly uses the subsidy to assist its agent in increasing its share of generic sales. The monopoly then extracts its agent's profits from generic sales using the licensing fee,  $T$ . The monopoly uses a positive markup when it sells to a single firm and  $C > c$ . The monopoly always uses a positive markup when it sells to two firms. As  $C$  increases, the new-product price becomes more sensitive to generic sales; the equilibrium markup rises with  $C$  if the monopoly sells to a single firm and decreases with  $C$  if it sells to two firms. Figure 3, by illustrating how  $m$  varies with respect to  $C$  for one or two vendors, helps explain why selling to a second vendor increases the new-product price when  $C < c$  and decreases that price for  $C > c$ , as Figure 1 shows. For example, when  $C < c$ ,  $m$  is negative with one vendor and positive with two vendors, so adding a second vendors raises the price of the new good.

### 3.4.1 The effect of monopoly entry

These results above compare the one-vendor and two-vendor equilibria, conditional on monopoly entry. We now study the effect of monopoly entry.

The downstream firms have the same level of profits regardless of whether the upstream monopoly sells to one or to both firms. We calculate this profit level and subtract the equilibrium

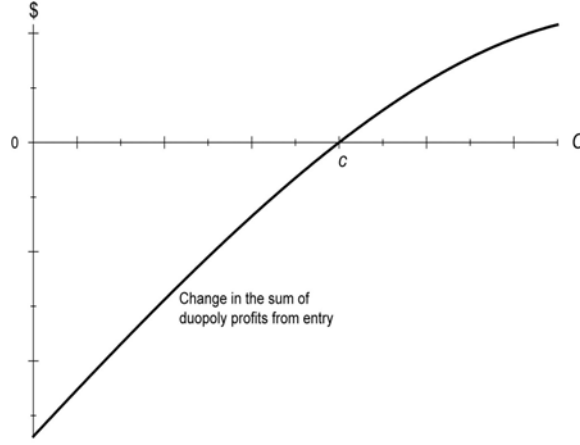


Figure 4: Change in the sum of the downstream profits from the entry of the upstream monopoly.

duopoly profits prior to entry of the upstream monopoly. This difference is

$$\left[ \frac{1}{36} a^2 (b - C) \frac{4b^2 - cb - 3Cc + C(b - C)}{(Cc - b^2)^2 b} \right] (C - c).$$

The term in square brackets is always positive, so the sign of the expression equals the sign of  $C - c$ , which implies

**Remark 8** For  $C < c$ , the monopoly extracts some of the pre-entry oligopoly rent, in addition to all of the extra rent that arises from the new product. For  $C > c$ , the downstream firms obtain some of this additional rent.

Figure 4 illustrates the effect of monopoly entry on duopoly profits.

That monopoly entry reduces duopoly profits is consistent with the comparative statics of the equilibrium markup. We noted that the monopoly uses a subsidy when it sells to a single vendor given that  $C < c$ . This subsidy causes the non-vendor, Firm 2, to face strong competition and it erodes that firm's profits. Our assumption about the first-stage equilibrium means that the monopoly uses the transfer to drive profits of its vendor(s) to the level received by a non-vendor in the one-vendor regime.

We also have

**Remark 9** For  $C < c$ , entry by the new-product monopoly increases consumer welfare, regardless of whether the monopoly sells to one firm or two.

This claim follows immediately from Lemma 2 in Appendix A.4 and because  $\mathbf{q}_n = 0$  before the monopoly enters. Simulations indicate that even for  $C > c$ , consumer surplus is higher when the upstream monopoly enters the market. That is, consumers benefit from the new product.

## 3.5 Robustness

This section examines the robustness of our results with respect to our assumptions about the monopoly's power vis a vis the downstream firms, and about the demand function.

### 3.5.1 Robustness with respect to monopoly power

Downstream firms in our model have market power with respect to consumers but not with respect to the monopoly. To consider bilateral monopoly, we would need an entirely different model. However, our model provides a simple means of changing the relative power of upstream and downstream firms. Assumptions 1 and 2 imply that downstream firms' reservation profit equals the endogenous level  $\pi_1^*(1)$ . We saw that for  $C < c$  the monopoly extracts some of the downstream firms' pre-entry rent, so that entry by the monopoly lowers downstream firms' profits.

To model the situation where downstream firms have greater power vis a vis the monopoly, we can replace Assumptions 1 and 2 with the assumption that a vendor's profits are no less than the maximum of the pre-entry profit,  $\pi^e$ , and the equilibrium profit of the non-vendor. This constraint changes the equilibrium relative to our earlier results only if  $C < c$ . We therefore report results only for this case. (Details are in Appendix A.5.)

Here, the monopoly chooses  $m$  to induce its vendor to sell at the level of the Stackelberg leader. In contrast, under our earlier assumption (Section 3.1) the monopoly induces its vendor to behave more aggressively to reduce the non-vendor's profit and thereby increase the transfer it extracts from its agent (Remark 1). Consequently, when the monopoly sells to a single vendor, consumers are better off under the original equilibrium assumption, compared to this alternative assumption. We can also show that this alternative assumption does not change consumer welfare when the monopoly sells to two vendors. Nevertheless for the linear model, if the monopoly is constrained to give its agents profits that are at least equal to the ex ante profits, consumers still prefer the monopoly to sell to a single vendor rather than to two vendors when  $C < c$ .

Simulations show that under this alternative assumption about downstream firms' market power, the upstream monopoly strictly prefers to sell to two agents when  $C < c$  for  $F$  sufficiently small. For larger values of  $F$ , the monopoly prefers to sell to a single agent. Thus, even under this alternative assumption, the monopoly may prefer to sell to either one or two vendors, while consumers always benefit from having a single vendor. The downstream firms are indifferent, because their profits are fixed at the ex ante level in both cases. Thus, our major results are robust to assumptions about the extent of monopoly power vis a vis the downstream firms.

### 3.5.2 Robustness with respect to demand function parameters

Our assumption that the own-quantity effects in the two demand functions are equal amounts to a choice of units, but the assumption that the inverse demand function intercepts are equal is a parameter restriction. Here we consider the effects of allowing the demand intercept of the new product,  $A$ , to differ from the demand intercept of the generic equation,  $a$ , so that  $A = a + \theta$ . That is, we now allow consumers to have a different willingness to pay for the new product. That is, consumers' reservation prices, net of production costs, differ. Appendix A.6 contains the details.

The requirement that  $A > 0$  bounds  $\theta$  from below by  $-a$ . The empirically relevant case is where  $\theta > 0$ , so the reservation price minus the unit production cost is greater for the new product than for the generic. We emphasize that case here, but the Appendix provides the formulae for general  $\theta$ .

Remark 4 does not depend on the sign of  $\theta$ . The monopoly prefers to sell to two vendors if  $F$  is small, and prefers to sell to a single vendor for large  $F$ .

Remark 3 continues to hold for "moderate"  $\theta$ , but if  $\theta$  exceeds a critical value and  $C$  is sufficiently small, both the generic price and the new price are lower with two firms. (The Appendix gives the formula for the critical value of  $\theta$ .) Figure 5 illustrates this possibility with  $\theta = 95$  and the parameter values used in the previous figures. Thus, Remarks 5 and 6 can be overturned if  $\theta$  is sufficiently large. Thus, we have

**Remark 10** *If the reservation price, net of production cost, of the new product is much greater than that of the generic ( $\theta$  is large) and the income elasticity of the new product is sufficiently greater than that of the generic ( $C$  is small relative to  $c$ ), then consumers prefer the monopoly to use two vendors. If  $F$  is sufficiently large, the monopoly prefers to use one vendor. In this circumstance, consumers benefit from MUD.*

Depending on the magnitude of  $F$  and other parameters, when the interests of consumers and the monopoly clash, an MUD rule might either increase or decrease total welfare. For example,  $F$  might be such that monopoly profits are only slightly greater with a single distributor, but consumers' welfare is much higher with two vendors.

When the monopoly sells to two vendors, the markup is positive and decreasing in  $C$ , as Remark 7.ii states for  $\theta = 0$ . In addition, the markup increases with  $\theta$ , as we would expect. However, if the monopoly sells to a single firm and  $\theta$  exceeds the critical value mentioned above, the markup is nonmonotonic in  $C$ . It is positive for large and for small values of  $C$  and negative for values of  $C$  close to but less than  $c$ .

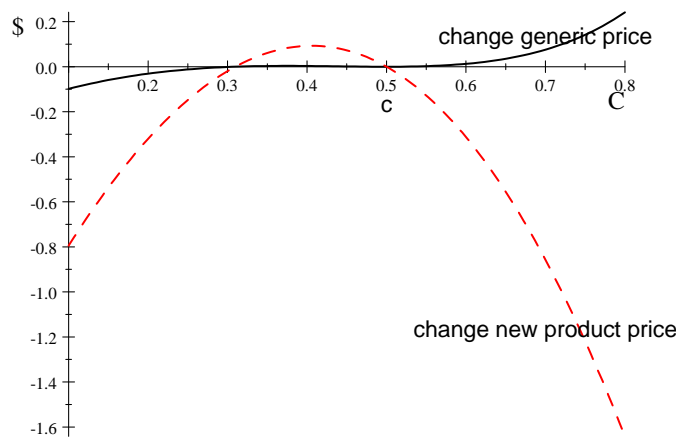


Figure 5: Change in prices if the monopoly sells to two rather than to one firm

## 4 Conclusions

We consider an industry where upstream firms sell to final consumers using downstream firms. Upstream, a competitive industry produces a generic product, and a monopoly produces a new good (such as Apple’s iPhone). The upstream monopoly may use one or more downstream vendors. In most of our models, we assume that the downstream market is oligopolistic with quantity-setting firms. The firms engage in a two-stage game. In the first stage, the upstream firm offers downstream firms contingent contracts and the downstream firms decide whether to accept those contracts.

A mandatory universal distribution (MUD) requirement may or may not benefit consumers. If the new product and the generic are not substitutes, the MUD restriction does not help consumers and harms the upstream monopoly so that it lowers the sum of consumer and producer welfare. If the downstream industry has many firms that are price takers, we get the same results regardless of whether the products are substitutes.

If the products are imperfect substitutes and the reservation price net of production cost of the new and generic products are the same or close to each other, and there is a downstream duopoly, there are four possible outcomes. The monopoly may want one vendor or two vendors and consumers might prefer either the monopoly’s choice or the alternative. If the new product has a higher income elasticity of demand than the generic, then consumers always prefer a single vendor in our almost symmetric linear model. Thus, this model shows that although there are cases where consumers might benefit from requiring the upstream firm to use a second vendor, those cases are unlikely because they require that the new product have a lower income elasticity of demand, compared to the generic.

However, if the reservation price (net of production costs) of the new product is much

greater than that of the generic, and if the fixed cost of using a second vendor is sufficiently high, consumers might prefer the monopoly to use two vendors, while the monopoly prefers to use a single vendor. This possibility occurs in the empirically relevant case, where the income elasticity of the new product exceeds that of the generic. This combination of parameter values provides an example where MUD benefits consumers, and possibly society. Of course, MUD may also be desirable for reasons that we have not considered, such as if having multiple vendors induces desirable differentiation and innovation.

## A Appendix: Technical material

Here we discuss the normal form of the stage game in which the monopoly offers firms symmetric contracts, and we then provide some computations that confirm Remarks in the text. The subsequent appendices contain details on consumer welfare and provides the background calculations for Section 3.5

### A.1 Normal-form contract-setting game

Section 3.4.1 notes that entry by the upstream monopoly reduces equilibrium downstream profits if  $C < c$ . Of course in a second-best setting, a new opportunity may reduce an equilibrium payoff. This result may appear to be surprising in our setting because one might think that the downstream firms would refuse to carry the monopoly's product and hence not suffer a loss. However, the monopoly can use contingent contracts to induce downstream firms to accept lower profits than they earned before the monopoly enters.

To illustrate this point, we consider a normal-form game in which the upstream monopoly offers downstream firms symmetric contracts to induce both firms to sell its product. The case where the monopoly uses asymmetric contracts to induce a single firm to act as its agent is similar.

The terms of the contract,  $(m, T)$ , are conditioned on whether one firm or both firms accept the offer. Each firm then simultaneously chooses the action  $x \in \{A, R\}$ , where  $A$  indicates that the firm accepts the offer, and  $R$  indicates rejection. If both downstream firms reject the contract, the outcome is the ex ante (prior to monopoly entry) Cournot equilibrium. This normal form game provides a simple way of showing the possibility that downstream firms might be harmed by the presence of the upstream monopoly. Here, we consider only circumstances where that result occurs:  $C < c$  in our almost symmetric linear model.

The monopoly can offer a menu such that if Firm  $i$  accepts and Firm  $j$  rejects, Firm  $j$ 's profit is small and Firm  $i$ 's profit is large. In this way, the monopoly can ensure that  $x = A$  is a dominant strategy. To ensure the dominance of  $x = A$ , the monopoly might have to accept a low profit in the non-equilibrium outcome where one firm accepts and the other rejects.

Table 1 illustrates the ability of contingent contracts to induce firms to accept contracts in equilibrium, even if they are both better off by rejecting the contract. (Firm 1's payoff is the first element in the pair of payoffs.) That is, the monopoly creates a prisoner's dilemma game. If both firms reject the contract, they obtain the ex ante payoff,  $\pi^e$ . If one firm accepts and the other rejects the contract, the profits of the firm that accepts,  $\pi^e + z > \pi^e$ , exceeds the ex ante level and the profits of the firm that rejects is  $\pi^e - 1$ . (Of course, the magnitude  $-1$  is arbitrary; it only matters that profits are below the ex ante level.) If both firms accept, their



profits are  $\pi^e - 1 + \frac{\varepsilon}{2}$ , which is also below the ex ante level for small  $\varepsilon$ . Accepting the contract is a dominant strategy if  $z > 0$  and  $\varepsilon > 0$ .

Firm 1\Firm 2	R	A
R	$\pi^e, \pi^e$	$\pi^e - 1, \pi^e + z$
A	$\pi^e + z, \pi^e - 1$	$\pi^e - 1 + \frac{\varepsilon}{2}, \pi^e - 1 + \frac{\varepsilon}{2}$

Table 1: Payoffs in a simultaneous move game.

## A.2 Confirmation of Remark 3

We consider the two cases, where the monopoly sells to a single vendor or two vendors. In both cases, we substitute the equilibrium markup, obtained from maximizing the monopoly's profits, into the firms' equilibrium decision rules. We then substitute these rules into the inverse demand functions to obtain the equilibrium generic and the new product prices when the monopoly sells to one or two firms. These prices are:

$$\begin{aligned}
\text{generic, one firm} & : \tau = \frac{1}{6} \frac{2ab^2 - cab + Cab - cCa - aC^2}{-Cc + b^2} \\
\text{new product, one firm} & : v = -\frac{1}{6} \frac{-3ab^3 + b^2Ca - abC^2 + 4abCc - 2cC^2a + aC^3}{b(-Cc + b^2)} \\
\text{generic, two firms} & : \delta = \frac{3}{2} \frac{2ab^2 - cab + Cab - cCa - aC^2}{9b^2 - 2c^2 - 2C^2 - 5Cc} \\
\text{new product, two firms} & : \epsilon = \frac{1}{2} \frac{9ab^3 - 4abc^2 - abC^2 - 4abCc - 7b^2Ca + 4b^2ca + 2cC^2a + aC^3}{b(9b^2 - 2c^2 - 2C^2 - 5Cc)}.
\end{aligned}$$

For both generic and new product prices, we subtract the equilibrium price with one firm from the equilibrium price with two firms:

$$\delta - \tau = \frac{1}{3} a (c - C)^2 (b + C) \frac{2b - c - C}{(-cC + b^2)(-5cC + 9b^2 - 2c^2 - 2C^2)} \geq 0 \quad (21)$$

$$\epsilon - v = \frac{1}{3} a (c - C) (b + C) (2b - c - C) \frac{3b^2 - 2cC - C^2}{b(-cC + b^2)(-5cC + 9b^2 - 2c^2 - 2C^2)} \quad (22)$$

Inequality (11) implies that the sign of  $\epsilon - v$  is the same as the sign of  $c - C$ .

## A.3 Confirmation of Remark 7

We first state a lemma that is also used in a proof in Appendix A.4

**Lemma 1** *For all values of  $m$ , regardless of whether the monopoly uses one or two vendors, sales in the generic market and the new market satisfy the relation*

$$\mathbf{q}_g = \frac{2a}{3b} - \frac{2c + C}{3b} \mathbf{q}_n. \quad (23)$$

**Proof.** When the upstream monopoly sells to both firms, we obtain the equilibrium conditions for aggregate sales in the two markets in a symmetric equilibrium, as functions of  $m$  using the linear model. We invert the formula for sales of the new product ( $j = n$ ) to obtain an expression for  $m$  as a function of aggregate sales,  $\mathbf{q}_n$ :

$$m = -\frac{1}{6} \frac{9b^2 - 2c^2 - 2C^2 - 5Cc}{b} \mathbf{q}_n - \frac{1}{3} \frac{2Ca + ca - 3ab}{b}. \quad (24)$$

We then substitute this equation into the equilibrium condition for aggregate generic sales,  $\mathbf{q}_g$ , as a function of  $m$  to obtain aggregate generic sales as a linear function of aggregate sales of the new product. The resulting relation is Equation 23. Given this constraint, a choice of, for example,  $\mathbf{q}_n$  determines the value of  $\mathbf{q}_g$  and also  $m$ . The values of these variables determine the monopoly's profits.

By its choice of  $m$ , the upstream monopoly selects a point on this line. The monopoly solves a maximization problem subject to two constraints, Equations 23 and 24.

When the monopoly sells to a single firm, its maximization is subject to the three equilibrium conditions: the two first-order conditions for generic sales and Firm 1's first-order condition for new product sales, which can be written as functions of  $m$ . We invert the equation for Firm 1's new-product sales to write  $m$  as a function of  $q_{n1} = \mathbf{q}_n$ . The result is

$$m = -\frac{1}{3} \frac{6b^2 - 4Cc - C^2 - c^2}{b} \mathbf{q}_n - \frac{1}{3} \frac{2Ca + ca - 3ab}{b}. \quad (25)$$

We use this equation to eliminate  $m$  from the remaining two equations (generic sales of the two firms) to obtain expressions for  $q_{g1}$  and  $q_{g2}$  as functions of  $\mathbf{q}_n$ . By adding the resulting two equations, we obtain the expression for aggregate generic sales as a function of aggregate new-product sales, again leading to Equation 23. ■

The equilibrium level of new product sales when the upstream monopoly sells to a single firm, conditional on  $m$ , is

$$\frac{3ab - ca - 3mb - 2Ca}{6b^2 - 4Cc - C^2 - c^2},$$

and the monopoly's optimal level of  $m$  is

$$m^*(1) = \frac{1}{6} a (b + C) (C - c) \frac{2b - C - c}{b(b^2 - Cc)}. \quad (26)$$

Conditional on the optimal level of  $m$ , the equilibrium level of new product sales with one vendor is

$$\mathbf{q}_n(1) \equiv \frac{1}{2} \frac{ab - Ca}{b^2 - Cc}.$$

The equilibrium level of new product sales when the monopoly sells to two firms, conditional on  $m$ , is

$$-2 \left( \frac{2Ca + ca - ch - 3ab - 2Ch + 3mb}{9bb - 2c^2 - 2C^2 - 5Cc} \right)$$

and the optimal level of  $m$  is

$$m^*(2) = \frac{1}{4} \frac{a(b-C)}{b}. \quad (27)$$

Equation 26 shows that when the monopoly sells to a single firm, it sets  $m < 0$  (a unit subsidy) if  $C < c$  and  $m > 0$  (a positive markup) if  $C > c$ . Equation 27 shows that the markup is always positive when the monopoly sells to two firms. In view of these two results,  $m^*(1) - m^*(2) < 0$  for  $C < c$ . To show that the markup with a single firm is larger than the markup with two firms when  $C$  is close to its upper bound,  $b$ , we need to compare the markup for large  $C$ . We have

$$\begin{aligned} m^*(1) - m^*(2) &= \frac{1}{6}a(b+C)(C-c) \frac{2b-C-c}{b(b^2-Cc)} - \frac{1}{4} \frac{a(b-C)}{b} \\ &= \frac{1}{12} \frac{a}{b(Cc-b^2)} [2C^3 - 2C^2b + 3C^2c - 7Cb^2 + Cbc - 2Cc^2 + 3b^3 + 4b^2c - 2bc^2]. \end{aligned}$$

Evaluating the term in square brackets at  $C = b$  (the supremum of  $C$ ) we have

$$(2C^3 - 2C^2b + 3C^2c - 7Cb^2 + Cbc - 2Cc^2 + 3b^3 + 4b^2c - 2bc^2) = -4b(b-c)^2 < 0.$$

Because  $Cc - b^2 < 0$ , we conclude that for  $C$  close to (but smaller than)  $b$ ,  $m^*(1) - m^*(2) > 0$ .

## A.4 Consumer welfare

**Proposition 1** *If  $c > C$  then a representative consumer has higher utility when the monopoly sells to a single downstream firm. If  $c < C$  and  $C - c$  is “sufficiently small” (in a sense made precise in the proof) then consumers have higher welfare when the monopoly sells to two downstream firms. The consumer is indifferent between the two alternatives if  $c = C$ .*

The proof of this Proposition relies Lemma 1 and on the following lemma that collects several properties of the indirect utility function that stem from the linear relationship described by Lemma 1. Let  $V(p_g, p_n, y)$  be the indirect utility function for a representative agent,  $y$  be income, and  $\lambda$  (a function of prices and income) be the marginal utility of income:

**Lemma 2** (i) *Holding  $y$  fixed, as aggregate sales of  $\mathbf{q}_n$  increases and  $\mathbf{q}_g$  adjusts as specified by Equation 23, the change in utility is*

$$\frac{1}{\lambda} \frac{dV}{d\mathbf{q}_n |_{\text{Equation 23}}} = \frac{1}{9} \left( \frac{9b^2 - 5Cc - 2C^2 - 2c^2}{b} \mathbf{q}_n + 2a \frac{c-C}{b} \right). \quad (28)$$

(ii) *For  $c \geq C$ ,  $dV/d\mathbf{q}_n > 0$  at every point on the line given by Equation 23, so utility reaches its maximum at the intercept of Equation 23*

$$(\mathbf{q}_g, \mathbf{q}_n) = \left( 0, \frac{2a}{2c+C} \right). \quad (29)$$

(iii) For  $c < C$ ,  $dV/d\mathbf{q}_n < 0$  for small  $\mathbf{q}_n$ , and  $V$  reaches a minimum at an interior point on the line where

$$\hat{\mathbf{q}}_n \equiv \frac{2a(C-c)}{9b^2 - 5Cc - 2C^2 - 2c^2}. \quad (30)$$

The maximum of  $V$  might be at either intercept of Equation 23.

**Proof.** (Lemma 2) (i) Totally differentiating the indirect utility function, holding  $y$  constant, dividing the result by  $\lambda$  and using Roy's identity implies

$$\begin{aligned} \frac{dV}{\lambda} &= \frac{1}{\lambda} \frac{\partial V}{\partial p_n} dp_n + \frac{1}{\lambda} \frac{\partial V}{\partial p_g} dp_g \\ &= -[\mathbf{q}_n dp_n + \mathbf{q}_g dp_g] \\ &= \mathbf{q}_n (bd\mathbf{q}_n + Cd\mathbf{q}_g) + \mathbf{q}_g (bd\mathbf{q}_g + cd\mathbf{q}_n) \end{aligned}$$

where the last line uses the total derivatives of the inverse demand equations (9). Divide both sides of the final equation by  $d\mathbf{q}_n$  to obtain

$$\frac{1}{\lambda} \frac{dV}{d\mathbf{q}_n} = \mathbf{q}_n \left( b + C \frac{d\mathbf{q}_g}{d\mathbf{q}_n} \right) + \mathbf{q}_g \left( b \frac{d\mathbf{q}_g}{d\mathbf{q}_n} + c \right).$$

Simplify this expression by using Equation 23 to eliminate  $\mathbf{q}_g$ , and noting that along the line in Equation 23,  $\frac{d\mathbf{q}_g}{d\mathbf{q}_n} = -\frac{2c+C}{3b}$ .

(ii) Because  $\lambda > 0$ , the sign of the right side of Equation 28 is the sign of the change in indirect utility due to an increase in  $\mathbf{q}_n$ , evaluated on the line given by Equation 23. By Inequality 11, the coefficient of  $\mathbf{q}_n$  on the right side of equation (28) is positive, so for  $c \geq C$ ,  $V$  is maximized at the corner given by Equation 29.

(iii) For  $c < C$ ,  $V$  is decreasing on this line in the neighborhood of the corner  $(\mathbf{q}_g, \mathbf{q}_n) = (\frac{2a}{3b}, 0)$ . Setting  $dV = 0$  implies Equation 30. Finally, we need to show that this value of  $\mathbf{q}_n$  is less than the value at the intercept,  $\frac{2a}{2c+C}$ . Subtracting these two values we have

$$\frac{2a(C-c)}{9b^2 - 5Cc - 2C^2 - 2c^2} - \frac{2a}{2c+C} = -6a \frac{3b^2 - 2Cc - C^2}{(9b^2 - 5Cc - 2C^2 - 2c^2)(2c+C)} < 0$$

where the inequality follows from Inequality 11. ■

We now provide the proof of Proposition 1.

**Proof.** Conditional on the optimal level of  $m$  (see Appendix A.3), the equilibrium level of new product sales with two vendors is

$$\mathbf{q}_n(2) \equiv \frac{1}{2} a \frac{9b - 5C - 4c}{9b^2 - 2c^2 - 2C^2 - 5Cc}.$$

The difference between new product sales in the two cases is

$$\mathbf{q}_n(1) - \mathbf{q}_n(2) = a(b+C)(c-C) \frac{2b-c-C}{(b^2-Cc)(9b^2-2c^2-2C^2-5Cc)}.$$

Inequality (11) implies that the sign of  $\mathbf{q}_n(1) - \mathbf{q}_n(2)$  is the same as the sign of  $c - C$ .

If  $c > C$  so that  $\mathbf{q}_n(1) > \mathbf{q}_n(2)$ , consumer welfare is higher when the monopoly sells to a single firm, because utility is increasing in  $\mathbf{q}_n$  by Lemma 2 part (ii).

If  $C > c$  so that  $\mathbf{q}_n(1) < \mathbf{q}_n(2)$ , by Lemma 2 part (iii),  $V$  is increasing in  $\mathbf{q}_n$  for  $\mathbf{q}_n > \hat{\mathbf{q}}_n$ . Therefore, for  $C > c$ , a sufficient condition for consumers to be better off with two downstream firms selling the new product is  $\mathbf{q}_n(1) - \hat{\mathbf{q}}_n > 0$ . Using the definition of  $\hat{\mathbf{q}}_n$  in Equation (30) we have

$$\mathbf{q}_n(1) - \hat{\mathbf{q}}_n = \frac{1}{2}a \frac{\gamma}{(Cc - b^2)(-9b^2 + 2c^2 + 2C^2 + 5Cc)} \quad (31)$$

where

$$\gamma \equiv 9b^3 + (-13C + 4c)b^2 + (-2c^2 - 2C^2 - 5Cc)b - 2c^2C + 2C^3 + 9C^2c. \quad (32)$$

Because the denominator in the last line of Equation (31) is positive, a necessary and sufficient condition for  $\mathbf{q}_n(1) - \hat{\mathbf{q}}_n > 0$  is  $\gamma > 0$ . Define  $\varepsilon \equiv C - c > 0$  and write  $\gamma$  in terms of  $\varepsilon$ :

$$\gamma = 2\varepsilon^3 + (-2b + 15c)\varepsilon^2 + (-9bc - 13b^2 + 22c^2)\varepsilon + 9(b + c)(-c + b)^2.$$

This expression shows that for small  $\varepsilon$ ,  $\gamma > 0$ . A sufficient condition for  $\gamma > 0$  is that  $\varepsilon$  is smaller than the smallest positive root of  $\gamma = 0$ .

If  $c = C$  then  $\mathbf{q}_n(1) - \mathbf{q}_n(2)$ , so sales of both the new and the generic product are the same regardless of whether the monopoly sells to one firm or two firms. Consequently, consumer welfare is also the same in the two cases. ■

## A.5 Robustness with respect to monopoly power

Here we consider how our results change as downstream firms gain power relative to the monopoly, eliminating the possibility that monopoly entry lowers downstream profits. In this alternative, a downstream firm accepts a contract if and only if its equilibrium profit under that contract is at least as large as its ex ante profit and is also at least as large as the profit of the rival that did not receive or accept a contract. With this restriction, when the monopoly makes an offer that results in Firm 1 being the only vendor, its problem is

$$\hat{\Pi}(1; F) = \max_{m, T} [mq_{n1}^*(1, m) + T - F] \text{ subject to } \pi_1^*(1, m, T) \geq \max\{\pi_2^*(1, m), \pi^e\}. \quad (33)$$

For our linear model, the binding constraint is  $\pi_1^*(1, m, T) \geq \pi^e$  when  $C < c$  and  $\pi_1^*(1, m, T) \geq \pi_2^*(1, m)$  when  $C > c$ . That is, the constraint that the agent receive a profit that is no smaller than the ex ante profit changes the problem only for  $C < c$ . We restrict attention to this part of parameter space, because we are interested in situations where the alternative assumption

about monopoly power affects the outcome. We consider the effect of the new constraint on the equilibrium outcome.

Using the constraint on the level of the agent's profits ( $\pi_1^*(1, m, T) \geq \pi^e$  for  $C < c$ ) to eliminate the transfer, the monopoly's problem when it sells to a single firm is

$$\hat{\Pi}(1; F) = \max_m \underline{p_g q_{g1}^*(1, m) + p_n q_{n1}^*(1, m)} - F - \pi^e. \quad (34)$$

In contrast to the problem in Equation 3, the final term in the maximand in Equation 34 is a constant. Here, the monopoly chooses  $m$  to induce its vendor to sell at the level of the Stackelberg leader. In contrast, under our earlier assumption (Section 3.1) the monopoly induces its vendor to behave more aggressively so as to reduce the non-vendor's profit and thereby increase the transfer it extracts from its agent. Consequently, when the monopoly sells to a single vendor, consumers are better off under the original equilibrium assumption, than under this alternative assumption. Where the monopoly sells to two vendors,  $\pi^e$  replaces the last term,  $\pi_2^*(1)$ , in the maximand in Equation 7. However, as we noted in our discussion of Equation 7, this constant does not affect the equilibrium value of  $m$  and therefore does not affect consumer welfare. That is, this alternative assumption decreases consumer welfare when the monopoly sells to a single vendor and does not change consumer welfare when the monopoly sells to two vendors.

Nevertheless, for the almost symmetric linear model, we can show that if the monopoly is constrained to give its agents profits that are at least equal to their ex ante profits, consumers prefer the monopoly to sell to a single vendor rather than to two vendors when  $C < c$ . To demonstrate this claim, we solve the optimization problem in Equation 34 to obtain the equilibrium value of  $m$  and substitute this into the equilibrium sales rules, and then substitute these into the inverse demand functions to obtain the equilibrium prices when the monopoly sells to a single agent. (Our alternative assumption about the equilibrium contract does not alter the equilibrium value of  $m$ , or the resulting prices, when the monopoly sells to two vendors.) The difference in the generic price, in moving from one vendor to two vendors is

$$\frac{3}{2} \frac{a(c-C)^2(b+C)(2b-c-C)}{(9b^2-5cC-2c^2-2C^2)(9b^2-7cC-c^2-C^2)} > 0,$$

and the difference in the price of the new product is

$$\frac{3}{2} \frac{a(c-C)(b+C)(3b^2-2cC-C^2)(2b-c-C)}{b(9b^2-5cC-2c^2-2C^2)(9b^2-7cC-c^2-C^2)} > 0,$$

where the inequalities follow from Equation 11 and the assumption  $C < c$  (for the second inequality).

## A.6 Robustness with respect to demand function parameters

The monopoly still prefers to sell to two firms if and only if the cost  $F$  is sufficiently small. Its increase in profits from selling to two rather than to 1 firm (exclusive of the additional cost  $F$ ) is

$$\frac{1}{9} (c - C)^2 \frac{(-2ab^2 + aC^2 + Abc - AbC + acC)^2}{b(9b^2 - 2c^2 - 2C^2 - 5cC)(-cC + b^2)^2} > 0,$$

which is independent of  $\theta$ .

Calculations parallel to those described in Appendix A.2 show that the increase in the generic price if Apple sells to two rather than to one firms is

$$\delta - \tau = \frac{1}{3} \frac{(c - C)^2}{(b^2 - cC)(9b^2 - 5cC - 2c^2 - 2C^2)} (a(C + b)(2b - C - c) + b\theta(C - c)).$$

The equation simplifies to Equation 21 for  $\theta = 0$ . A sufficient condition for the generic price to be higher when the monopoly sells to two rather than to one firm is  $b\theta(C - c) > 0$ . For  $b\theta(C - c) < 0$  and sufficiently large in absolute value, the generic price is lower when the monopoly sells to two firms. For  $C \neq c$ , define

$$\bar{\theta} = \frac{a(C + b)(2b - C - c)}{b(c - C)},$$

which has the same sign as  $c - C$ .

The necessary and sufficient condition for  $\delta - \tau > 0$  is

$$\theta \left\{ \begin{array}{l} > \bar{\theta} (< 0) \\ < \bar{\theta} (> 0) \end{array} \right\} \text{ for } \left\{ \begin{array}{l} C - c > 0 \\ C - c < 0 \end{array} \right\} \quad (35)$$

The empirically relevant case is where both  $\theta > 0$  (the reservation price for the new product, net of production costs, exceeds the reservation price for the generic), and where  $C < c$  (the income elasticity of the new product exceeds that of the generic). This situation corresponds to the second line of Inequality 35; here the generic price is *lower* when the monopoly sells to two firms rather than to one firm, if  $\theta > \bar{\theta}$ .

The difference between the new product price when the monopoly sells to two firms rather than to a single firm is

$$\epsilon - v = \frac{1}{3} \frac{(3b^2 - 2Cc - C^2)(c - C)}{b(b^2 - Cc)(9b^2 - 5Cc - 2C^2 - 2c^2)} (a(C + b)(2b - C - c) + (C - c)b\theta),$$

which simplifies to Equation 22 for  $\theta = 0$ . The necessary and sufficient condition for  $\epsilon - v > 0$  is

$$\theta \left\{ \begin{array}{l} < \bar{\theta} (< 0) \\ < \bar{\theta} (> 0) \end{array} \right\} \text{ for } \left\{ \begin{array}{l} C - c > 0 \\ C - c < 0 \end{array} \right\} \quad (36)$$

As noted above, the empirically relevant setting is  $C < c$  and  $\theta > 0$ , corresponding to the second line of Inequality 36. In this case, the new product price is higher when the monopoly sells to two firms rather than to one firm if and only if  $\theta$  is not greater than  $\hat{\theta}$ .

Consequently, if  $C < c$  and  $\theta > \bar{\theta} (> 0)$ , both the new and generic prices are lower when the monopoly sells to two vendors.

The markup when the monopoly sells to a single firm is

$$m = \frac{(C - c)}{6b(b^2 - Cc)} (a(C + b)(2b - C - c) + b(C - c)\theta).$$

The necessary and sufficient condition for this markup to be positive is

$$\theta \left\{ \begin{array}{l} > \bar{\theta} (< 0) \\ > \bar{\theta} (> 0) \end{array} \right\} \text{ for } \left\{ \begin{array}{l} C - c > 0 \\ C - c < 0 \end{array} \right\}.$$

If apple sells to both firms its markup is

$$m = \frac{1}{4b} (b\theta + a(b - C))$$

which is positive provided that  $\theta > \frac{a}{b}(C - b)$ , a negative number.



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