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Apple's Agency Model and the Role of Resale Price Maintenance

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Apple's Agency Model and the Role of Resale Price Maintenance[1]

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Abstract: The agency model is a business format used by online digital platform providers (such as Apple and Google) in which retail pricing decisions are delegated to upstream content providers subject to a fixed revenue-sharing rule. In a non-cooperative setting with competition both upstream and downstream, we show that the agency model can lead to higher or lower retail prices depending on the firms' revenue-sharing splits and the relative substitution between goods and between platforms. Even if industry-wide adoption of the agency model would lead to higher profits for all firms, there may be equilibria in which it is not universally adopted. Most-favored-nation clauses (used by Apple in the controversial e-books case) can be used in such settings to increase retail prices and induce adoption.

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1 Introduction

The agency model is often adopted by online digital platform providers (such as Apple and Google) in their dealings with upstream content providers (such as e-book publishers and app developers).[2] This business model has two key ingredients. The first is that the downstream platforms delegate retail pricing decisions to the upstream content providers. The second is that the platform providers are compensated via a fixed revenue-sharing rule. Thus, for example, Rovio Entertainment controls the retail price of its popular game Angry Birds, and Apple keeps 30% of the revenue created on each sale made on its platform.[3]

The pricing aspect of the agency model is, in economic terms, similar to resale price maintenance (RPM), about which much has been written. What is unusual about the agency model, however, is that it is the downstream firms — not the upstream firms — who decide whether to use RPM. This has led to controversy, in part because little is known about the competitive effects of the agency model, or why the agency model is adopted.

Notably, the usual (procompetitive) explanations for RPM do not apply. For example, it has been alleged in other contexts that RPM can reduce free-riding on pre-sale services (Telser, 1960), stimulate inter-brand competition by providing quality certification (Marvel and McCafferty, 1984) or by fostering demand-enhancing activities (Mathewson and Winter, 1984; Winter 1993) and ensure that downstream firms have sufficient margins to maintain adequate supplies of inventory (Deneckere et al., 1996; Krishnan and Winter, 2007). But these explanations have no bite when it is the downstream firms who are deciding whether to adopt the agency model (to prevent free-riding on a retailer's pre-sale services, for example, RPM has to be imposed on the downstream firms that want to free ride; it cannot be an option for them).[4] Moreover, the role of the agency model cannot be to mitigate the well-known problem of double marginalization because there is no double-

[2] The agency model is also used by other online platforms, including eBay and Amazon Marketplace, and by mobile operators in the market for mobile content messages (see Foros et al., 2009).

[3] Apple's 70/30 revenue split is fixed in advance (non-negotiable) and the same for all content providers. Thus, for example, News Corp (Murdoch) does not obtain a better deal than a small, insignificant e-book publisher or app developer (see Isaacson, 2011, and United States v. Apple Inc, 12 Civ. 2826 (DLC)). Google and other online platforms also employ a straight 70/30 revenue split (although Google used to have an 80/20 split). One exception is the split Microsoft uses for apps at its Windows Store. It starts out with a 70/30 split, but then goes to 80/20 if the app's sales exceed $25,000 (Marketing Week, 2011).

[4] Similarly, to prevent undercutting of the firm that is providing the quality certification, or to preserve downstream profit margins in order to maintain adequate incentives to carry inventory, RPM must be imposed on retailers. One cannot allow each retailer to decide on its own whether it wants to have RPM.

marginalization problem when firms engage in revenue sharing and, as is likely to be the case with digital products, the marginal costs of distribution are zero or close to zero.

The agency model is also controversial because of the recent investigations in the U.S. and Europe into Apple's use of the agency model on e-books.[5] Although Apple and Google both adopted the agency model without raising significant concerns from antitrust authorities when the first smartphones were introduced in 2008, this changed when Apple entered the e-books market in 2010. In filings made by the U.S. Department of Justice in 2012, it was asserted that Apple's agency model in conjunction with certain clauses (see below) in its contracts had resulted in higher retail prices for consumers. It was also asserted that the rapid industry-wide adoption of the agency model after Apple entered the e-books market was the result of collusion between Apple and the five largest book publishers in the U.S.[6]

Lastly, the agency model is controversial because the contracts often contain most-favored-nation (MFN) clauses that restrict the retail price at which the upstream firms can offer their goods for sale. It is, for example, known from Apple's use of the agency model on e-books that it had an MFN clause that prevented book publishers from selling their e-books at higher retail prices on Apple's iBookstore than they were sold for elsewhere.[7]

In this paper, we allow for both upstream and downstream competition, where the upstream firms serve all downstream firms. We consider the downstream firms' incentives to delegate pricing control to the upstream firms, and we ask the following three questions:

1. when will the agency model lead to higher prices?

2. when will the agency model be adopted?

3. what is the role of MFN clauses?

Our benchmark is revenue-sharing arrangements in which the downstream firms retain control of the retail prices.[8] Moreover, we conduct our analysis in a static non-cooperative

[5] Documents from the European Commission's proceedings in the e-books investigation are available at http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=1_39847. See the OFT press release (29 August 2013): http://www.oft.gov.uk/news-and-updates/press/2013/60-13#.Umj2_PmSwTk.

[6] The judge in the e-books case ruled that Apple was guilty of conspiring with the publishers to fix e-books prices. A key issue was whether Amazon was pressured into using the agency model, or whether it would have adopted the agency model anyway. See United States v. Apple, 12 Civ. 2826 (DLC).

[7] United States v. Apple, 12 Civ. 2826 (DLC), July 10, 2013. "The MFN guaranteed that the e-books in Apple's e-bookstore would be sold for the lowest retail price available in the marketplace." p.47.

[8] This allows us to isolate the effects of the delegation without changing the way firms are compensated.

setting. Thus, for example, we do not allow RPM to be used by powerful retailers to facilitate a retail cartel (as in Yamey, 1954), nor do we allow RPM to be used by firms to facilitate tacit collusion when retail prices are observable (as in Jullien and Rey, 2007).

In answer to our first question, we find that delegating pricing control to the upstream firms may lead to higher or lower retail prices depending on whether the platforms' revenue-sharing splits are the same or different, and whether the willingness of consumers to substitute between goods is higher or lower than their willingness to substitute between platforms. In particular, we show that a platform that keeps a larger share of the revenue for itself will have higher retail prices than its rival when both adopt the agency model. We also show that retail prices will tend to be higher when both firms adopt the agency model than when neither firm adopts it if substitution is relatively greater downstream. Thus, the agency model is not intrinsically anticompetitive. Depending on substitution patterns, prices may be higher or lower under the agency model. By giving control of the retail prices to the upstream firms, the downstream platforms simply trade one type of pecuniary externality (due to competition between platforms) for another (due to competition between goods).

In answer to our second question, we demonstrate that when the revenue splits are the same for both platforms, all firms (upstream and downstream) benefit from industry-wide adoption of the agency model when it increases prices. However, this does not mean that it will be adopted. We show that when the platform providers can choose whether or not to adopt the agency model, multiple equilibria may arise. In particular, there may be a prisoner's dilemma in which each platform provider would have an incentive to deviate from the agency model even when industry-wide adoption would lead to higher prices and profits for all. There may also be equilibria in which no firm adopts the agency model.

Lastly, in answer to our third question, we find that MFN clauses can be used to overcome the prisoner's dilemma that might otherwise arise. In particular, such clauses can nudge the industry toward agency adoption (by making adoption a weakly dominant strategy for the downstream platforms), thereby leading to higher prices than would otherwise have been the case. Moreover, this is so even if only one platform provider has an MFN clause, and even if the MFN clause has no effect on the downstream firms' revenue-sharing

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Furthermore, Apple (among others) uses revenue-sharing also when they retain control of retail pricing. When Apple established its iTunes store, for example, it declined to delegate pricing control to the upstream firms, opting instead to offer each song for sale at a price of 99 cents. However, the 70/30 revenue split is used for music as well as for apps and e-books (where the agency model is adopted). See Isaacson (2011).

splits.[9] Thus, we find that rapid industry-wide adoption of the agency model may occur naturally in practice, and need not be the result of "pressure" from the upstream firms.

Our analysis contributes to the vertical-contracting literature in several ways. First, most models of vertical contracting assume either that one level (upstream or downstream) is monopolized, or that each downstream firm sells only one upstream firm's goods. In contrast, we assume imperfect competition at both levels and allow each downstream firm to sell multiple upstream firms' goods. The papers by Lal and Villas-Boas (1998), Dobson and Waterson (2007), Rey and Verge (2010), and Johnson (2013a,b) are similar to ours in that regard. Of these, only Johnson allows the firms to engage in revenue sharing.[10] Unlike us, he adopts the wholesale model (compensation to the upstream firms is in the form of a linear wholesale price) as his benchmark when analyzing the competitive effects of RPM.

Second, we offer a new explanation for RPM in which the pricing effects depend on the firms' revenue shares and whether competitive pressures are weaker upstream or downstream. We find that RPM might, for instance, lead to lower retail prices even in the absence of a double marginalization problem. In other settings, however, it can lead to higher retail prices. This is so even in the absence of a cartel (Yamey, 1954; Jullien and Rey, 2007), a first-mover advantage by the firm or firms using RPM (Shaffer, 1991; Foros et al, 2011), a commitment to maintain higher retail markups (Rey and Verge, 2010), or a potential entrant that threatens to enter and destroy surplus (Asker and Bar-Isaac, 2014).[11]

Third, we contribute to the literature on MFN clauses. It is well known that MFN clauses can be used as a commitment device to raise prices in inter-temporal settings (Cooper, 1986; Neilson and Winter, 1993; Schnitzer, 1994; Hviid and Shaffer, 2012). It is also well known that MFN clauses can lead to higher prices in bargaining settings in which contracts are negotiated sequentially (Cooper and Fries, 1991; and Neilson and Winter, 1994). Closer to us, Johnson (2013b) suggests that MFN clauses can remove the platforms' incentives to provide higher revenue shares to content providers in order to induce a lower

[9]This is consistent with the stylized facts in the e-books case, where, for instance, the revenue-sharing split that Apple used for e-books (where it had an MFN clause) was the same as the revenue-sharing split that it used for music (where it did not adopt the agency model and thus did not have an MFN clause).

[10]In contrast to us, he finds that the upstream firms cannot benefit from the agency model (without MFN clauses), and that it always leads to lower retail prices relative to his wholesale model benchmark.

[11]Our analysis takes place in a non-cooperative, single-period setting, thus ruling out tacit or explicit collusion as an explanation, and there is no potential entrant at the upstream level, thus ruling out the concern in Asker and Bar-Isaac (2014). Moreover, there is no first-mover advantage to exploit when some firms adopt RPM and others do not, as in Shaffer (1991) and Foros et al. (2011), and no manipulation of the retail markups when both wholesale prices and fixed fees are feasible, as in Rey and Verge (2010).

retail price (and a higher retail price for goods sold through the rival's platform). Although this implication of MFN clauses also holds in our model, we find that MFN clauses may in addition adversely affect prices even if they have no effect on the firms' revenue shares.

Fourth, we contribute to the literature on strategic delegation that has been inspired by the works of McGuire and Staelin (1983), Moorthy (1988), Rey and Stiglitz (1988), and Bonanno and Vickers (1988), among others. Typically, in this literature, firms commit to taking an action which, if observable, dampens competition. The observable commitment device in our setting is the delegation of pricing control to the upstream firms. Since this is a discrete choice, unlike in the aforementioned papers in the strategic-delegation literature, the delegation we consider is not always profitable even when it would dampen competition.

The rest of the paper is organized as follows. In Section 2 we present the model. First, in Section 2.1 we compare the retail prices that would arise when both firms adopt the agency model with the retail prices that would arise when neither firm adopts the agency model. In Section 2.2 we consider the adoption decisions of the downstream firms. In Section 2.3 we consider how MFN clauses impact adoption decisions and affect prices. In Section 2.4 we discuss an initial stage - prior to the adoption stage - where the revenue-sharing splits are endogenously determined. In Section 3 we conclude the paper. There we summarize our findings and discuss other factors that may affect the platforms' adoption incentives.

2 The Model

We consider a single-period setting in which there are two (upstream) content providers, indexed by $j = 1, 2$, and two (downstream) platform providers, indexed by $i = 1, 2$. Each downstream firm sells the goods of both upstream firms. We let the demand for good j (superscripts on variables) at downstream firm i (subscripts on variables) be given by:

$$x_i^j = q_i^j(p_1^1, p_1^2, p_2^1, p_2^2).$$

We assume that x_i^j is decreasing in p_i^j (i.e., downward sloping) and weakly increasing in each of the other prices (i.e., the products are gross substitutes) whenever x_i^j is positive. We also assume that the demands are symmetric between the firms and between the goods.[12]

[12]Formally, we assume that $q_i^j(a, b, c, d) = q_{-i}^j(c, d, a, b)$ and $q_i^j(a, b, c, d) = q_i^{-j}(b, a, d, c)$, for $i, j = 1, 2$.

Each downstream firm i keeps a share $s_i \in [0,1]$ of the revenue it earns from selling goods 1 and 2, and each upstream firm j gets $1 - s_i$ share of the revenue D_i earns from selling good j. Thus, we assume that D_i does not charge a different s_i to U^1 than it does to U^2 (nor would it want to in our model given the assumed symmetry). Moreover, we assume that the marginal costs of producing and distributing each good are zero. Writing $\mathbf{p} = (p_1^1, p_1^2, p_2^1, p_2^2)$, downstream firm i's profit given its revenue share s_i is thus

$$\Pi_{Di} = s_i \left(p_i^1 q_i^1(\mathbf{p}) + p_i^2 q_i^2(\mathbf{p}) \right), \tag{1}$$

and upstream firm j's profit, which depends on both s_1 and s_2, is

$$\Pi^{Uj} = (1 - s_1)\, p_1^j q_1^j(\mathbf{p}) + (1 - s_2)\, p_2^j q_2^j(\mathbf{p}). \tag{2}$$

With respect to the timing of the game, we assume that prior to the determination of retail prices, the downstream firms choose whether or not to delegate price setting to the upstream firms. We also assume that the revenue shares, s_1 and s_2, are exogenously given (alternatively, one can think of them as being determined prior to the downstream firms' decisions on delegation – see Section 2.4 for further discussion on this). Finally, we assume for now that the downstream firms do not use MFN clauses (this is relaxed in Section 2.3).

Our assumptions make use of several stylized facts. First, the revenue-shares are typically not negotiable in practice, and second, the major digital platforms appear to use a "one size fits all" approach for all content providers both within and across the product categories they participate in. Apple, for instance, uses the same 70/30-split for all services regardless of whether it delegates retail pricing decisions to the upstream content providers or not. See the discussion in the Introduction (in particular footnote 3) and Isaacson (2011).

2.1 When will the agency model lead to higher prices?

We now compare the case in which both downstream firms delegate retail pricing to the upstream firms (adopt the agency model) to the case in which both set their own prices. In the next subsection we endogenize the choice of whether to adopt the agency model. There we allow for an asymmetric outcome where only one of the two platforms does so.

In the no-delegation case, downstream firm i's optimization problem is given by

$$\max_{p_i^1, p_i^2} \Pi_{Di}. \tag{3}$$

The system of first-order conditions, $i = 1, 2$, that characterizes the Bertrand equilibrium in this case can, for a given s_i, be written as

$$\frac{\partial \Pi_{Di}}{\partial p_i^1} = s_i \left(p_i^1 \frac{\partial q_i^1}{\partial p_i^1} + q_i^1 + p_i^2 \frac{\partial q_i^2}{\partial p_i^1} \right) = 0, \quad (4)$$

$$\frac{\partial \Pi_{Di}}{\partial p_i^2} = s_i \left(p_i^2 \frac{\partial q_i^2}{\partial p_i^2} + q_i^2 + + p_i^1 \frac{\partial q_i^1}{\partial p_i^2} \right) = 0. \quad (5)$$

In contrast, in the delegation case (both downstream firms adopt the agency model), upstream firm j's optimization problem is given by:

$$\max_{p_1^j, p_2^j} \Pi^{Uj}. \quad (6)$$

It follows that the system of first-order conditions, $j = 1, 2$, that characterizes the Bertrand equilibrium in this case can, for a given s_1 and s_2, be written as

$$\frac{\partial \Pi^{Uj}}{\partial p_1^j} = (1 - s_1) \left(p_1^j \frac{\partial q_1^j}{\partial p_1^j} + q_1^j \right) + (1 - s_2) \left(p_2^j \frac{\partial q_2^j}{\partial p_1^j} \right) = 0, \quad (7)$$

$$\frac{\partial \Pi^{Uj}}{\partial p_2^j} = (1 - s_1) \left(p_1^j \frac{\partial q_1^j}{\partial p_2^j} \right) + (1 - s_2) \left(p_2^j \frac{\partial q_2^j}{\partial p_2^j} + q_2^j \right) = 0. \quad (8)$$

We presuppose that a unique equilibrium exists in both cases. For existence, we assume that the demands x_i^j are smooth whenever positive, that the Jacobian of the demand system is negative definite, and that each firm's profit is quasi-concave in its choice variables. For uniqueness, we assume that own effects dominate the sum of the cross effects on profits.[13]

There are several differences between conditions (4) and (5) and conditions (7) and (8). Note first that since s_i is the same for both goods, and enters (4) and (5) multiplicatively, equilibrium prices without delegation do not depend on whether s_i and s_{-i} are the same or different. In contrast, with delegation (when the upstream firms control the retail prices), equilibrium prices are independent of the revenue-sharing splits if and only if $s_i = s_{-i}$.[14]

Lemma 1 *When the downstream firms control the prices (no delegation), equilibrium retail prices are independent of revenue shares. When the upstream firms control the prices (delegation), equilibrium retail prices are independent of s_i and s_{-i} if and only if $s_i = s_{-i}$.*

[13] Thus, we assume that $\frac{\partial^2 \Pi^{Uj}}{(\partial p_i^j)^2} + |\frac{\partial^2 \Pi^{Uj}}{\partial p_i^j \partial p_{-i}^j}| + |\frac{\partial^2 \Pi^{Uj}}{\partial p_i^j \partial p_i^{-j}}| + |\frac{\partial^2 \Pi^{Uj}}{\partial p_i^j \partial p_{-i}^{-j}}| < 0$ for the case in which the upstream firms control the retail prices, and $\frac{\partial^2 \Pi_{Di}}{(\partial p_i^j)^2} + |\frac{\partial^2 \Pi_{Di}}{\partial p_i^j \partial p_{-i}^j}| + |\frac{\partial^2 \Pi_{Di}}{\partial p_i^j \partial p_i^{-j}}| + |\frac{\partial^2 \Pi_{Di}}{\partial p_i^j \partial p_{-i}^{-j}}| < 0$ for the case in which the downstream firms control the retail prices. See the extended discussion in Vives (1999), pp. 148-154.

[14] This can be seen by noticing that a simple division of the left and right-hand sides of (7) and (8) by $1 - s_i$ does not eliminate the left-hand sides' dependence on s_i and s_{-i} when s_i differs from s_{-i}.

Note second that when the upstream firms set the prices, upstream firm j's marginal profitability of increasing p_1^j is *decreasing* in s_2 (because $\frac{\partial q_2^j}{\partial p_1^j} > 0$ when consumers perceive the downstream firms as imperfect substitutes). This means that for a given s_1, the optimal p_1^j taking all other prices as given, will be *lower* the higher is s_2 (for a given s_2, the optimal p_2^j taking all other prices as given will be *lower* the higher is s_1). Conversely, upstream firm j's marginal profitability of increasing p_2^j is increasing in s_2,[15] which means that for a given s_1, the optimal p_2^j taking all other prices as given will be higher the higher is s_2 (for a given s_2, the optimal p_1^j taking all other prices as given will be *higher* the higher is s_1).

It follows from these implications that if, for example, s_i increases (i.e., D_i opts to keep a larger share of the revenue for itself), then U^j's incentive for a given s_{-i} is to sell relatively more of its good through D_i's rival and thus less through D_i. It can do this either by raising the price of good j at D_i by more than it raises the price of good j at D_i's rival, lowering the price of good j at D_i's rival by more than it lowers the price of good j at D_i, or by both raising the price of good j at D_i and lowering the price of good j at D_i's rival.

These findings, as well as other implications and differences, are summarized in the following lemma. We have (see Appendix for the proofs of all Lemmas and Propositions):

Lemma 2 *When the downstream firms control the prices (no delegation), all retail prices will be the same in equilibrium (i.e., $p_i^j = p_i^{-j}$ and $p_i^j = p_{-i}^j$ for all s_i, s_{-i}). When the upstream firms control the prices (delegation), retail prices in equilibrium will be such that*

- $p_i^j = p_i^{-j}$ *for all* s_i;
- $p_i^j = p_{-i}^j$ *if* $s_i = s_{-i}$;
- $p_i^j - p_{-i}^j > 0$ *if and only if* $s_i > s_{-i}$.
- $p_i^j - p_{-i}^j$ *is increasing in* s_i .

Lemma 2 implies that in both cases, the prices at a given downstream firm will be the same in equilibrium. When there is no delegation, the prices *across* the two downstream firms will also be the same. However, when there is delegation, the prices *across* the two downstream firms will be the same if and only $s_i = s_{-i}$. If these shares are not the same, then the firm whose revenue share is higher will have higher retail prices. Moreover, the

[15] Note that the second term in (8) must be negative because the first term, $\partial q_1^j / \partial p_2^j$, is positive.

difference between the two firms' prices will be increasing in s_i (an increase in s_i will cause U^j to modify its prices so as to stimulate sales through D_{-i} relative to D_i).

Having shown that the maximization problems in (3) and (6) can lead to different outcomes when s_i differs from s_{-i}, we now show that the maximization problems in (3) and (6) can lead to different outcomes even when $s_i = s_{-i}$.[16] The reason is that even when revenue shares are the same, the upstream and downstream firms focus on different things. When the downstream firms choose prices (no delegation), each cares more about stealing business from its rival than about whether a particular sale holding prices equal comes from good 1 or 2. In contrast, when the upstream firms choose prices (delegation), each cares more about the sales of its good versus its rival's good than about where its good is sold.

This has implications for setting prices. In the no-delegation case, for example, conditions (4), (5), and their analogs imply that in equilibrium, the unique price p satisfies

$$\left[p\frac{\partial q_i^j(\mathbf{p})}{\partial p_i^j} + q_i^j(\mathbf{p})\right] + p\frac{\partial q_i^{-j}(\mathbf{p})}{\partial p_i^j} \;=\; 0, \tag{9}$$

whereas in the delegation case (both firms adopt the agency model), when $s_1 = s_2$, conditions (7), (8), and their analogs imply that in equilibrium, the unique price p satisfies

$$\left[p\frac{\partial q_i^j(\mathbf{p})}{\partial p_i^j} + q_i^j(\mathbf{p})\right] + p\frac{\partial q_{-i}^j(\mathbf{p})}{\partial p_i^j} \;=\; 0. \tag{10}$$

Let $p = p^{**}$ denote the solution to (9) and $p = p^{aa}$ denote the solution to (10), and define $\mathbf{p}^{**} \equiv (p^{**}, p^{**}, p^{**}, p^{**})$ and $\mathbf{p}^{aa} \equiv (p^{aa}, p^{aa}, p^{aa}, p^{aa})$ to be the corresponding vectors of equilibrium prices (here "aa" denotes both downstream firms adopting the agency model). Then, it is straightforward to see by comparing (9) and (10) that the following must hold:

Proposition 1 *When $s_i = s_{-i}$, equilibrium retail prices in the two cases are*

- *the same with and without delegation if* $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} = \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$;
- *lower with delegation than without delegation if* $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} < \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$;
- *higher with delegation than without delegation if* $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$.

[16] This case is especially of interest because the revenue-sharing splits that have been observed in practice have thus far all been the same or very similar for the different downstream platform providers (perhaps in part because each recognizes that it would be disadvantaged if it were to assess a larger share for itself).

Proposition 1 states that if $s_i = s_{-i}$, then retail prices will be higher with delegation than without delegation if and only if there is more substitution at the downstream level (as measured by the price sensitivity of consumers between downstream firms) than at the upstream level (as measured by the price sensitivity of consumers between goods). Formally, $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j}$ measures the impact on the demand for good j at D_{-i} when D_i's price on good j changes (substitution between downstream firms), and $\frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$ measures the impact on the demand for U^{-j}'s good at D_i when D_i's price on good j changes (substitution between goods). Retail prices will be higher with delegation if and only if the former is greater.[17]

In practice, where the downstream platforms typically sell thousands of goods, the substitution between platforms may exceed the substitution between goods for some pairs of goods, but not for other pairs. In this case, we would expect to see higher retail prices on the former pairs and lower retail prices on the latter pairs when the upstream firms control the prices vis a vis when the downstream firms control the prices. It follows that even when delegation on average leads to higher or lower retail prices, the direction of the pricing changes need not be uniform across all goods for markets that are broadly defined.

The intuition for Proposition 1 is that when the downstream firms control the prices, they do a good job of internalizing the substitution between goods on their respective platforms, but succumb to head-to-head competition between themselves for the patronage of consumers. When consumer loyalty between retailers is relatively low, this can lead to fierce competition and result in low prices for consumers. In contrast, when the upstream firms control the prices (delegation), the substitution between platforms is internalized, but the firms compete to get consumers to buy their good over their rival's good. This too can lead to low prices for consumers, but only when the goods are perceived to be close substitutes. Thus, by giving control over prices to the upstream firms, the downstream firms can effectively trade one type of externality (substitution between downstream firms) for another type of externality (substitution between goods). As a result, prices can be higher or lower in the delegation case depending on the relative strengths of substitution.

When the substitution between downstream firms is relatively high, the joint profits of the downstream firms will increase by transferring control to the upstream firms. When

[17] The findings in Proposition 1 would hold even if the revenue-sharing splits in the delegation case were different from the revenue-sharing splits in the no-delegation case, as long as $s_i = s_{-i}$ in the delegation case. This is because retail prices in the no-delegation case do not depend on the revenue-sharing splits.

the substitution between goods is relatively high, the downstream firms' joint profits will increase by retaining control of the retail prices for themselves. These implications follow because equilibrium retail prices in both cases (with and without delegation) will generally be below the level that maximizes industry profits. When both firms choose the business format that induces the higher (symmetric) retail prices, therefore, both can move closer to the industry profit maximum. In the absence of mitigating factors (e.g., cost differences that might arise from implementing different formats) to suggest otherwise, this implies:

Corollary 1 *When $s_i = s_{-i}$, industry profits will be higher with delegation than without delegation if and only if competitive pressures are greater downstream than upstream.*

In this paper, competitive pressures are measured by the ease with which consumers are willing to substitute between goods (upstream) and between retailers (downstream). More generally, we would expect the same insights to extend to settings in which the factors that affect the competitive pressures upstream and downstream are more nuanced.[18] The general idea is that delegating pricing control to the level at which the competitive pressures are weaker would be expected, all else being equal, to result in higher industry profits.[19]

2.2 When will the agency model be adopted?

We now allow the downstream firms to decide whether to delegate control of the pricing decisions to the upstream firms (use the agency model) or to retain control for themselves.

Although many factors likely affect these decisions in practice (e.g., one side may have better information about demand, or there may be a perceived need to maintain upstream incentives to innovate, etc.),[20] here we focus solely on the pricing effects of the downstream

[18] For example, in the sale of e-books, e-book publishers might face less competitive pressure to set lower prices than they would otherwise if they also sell printed books (i.e., substitutes). And a firm that sells both e-books and e-book readers (i.e., complements) might be inclined to charge lower prices than they would otherwise if they only sold e-books. An accurate assessment of the actual competitive pressures faced by the upstream and downstream firms would need to take these additional factors into account.

[19] We say all else being equal because the presumption in Proposition 1 and Corollary 1 is that the downstream firms have the same revenue-sharing splits. If they do not, for example, if $s_i > s_{-i}$, then it is possible for industry profits to be higher in the delegation case than in the no-delegation case even when competitive pressures are *higher* upstream (this can happen, for example, if D_i's setting of $s_i > s_{-i}$ causes the prices at both downstream firms to increase relative to what they would be if D_i were to set $s_i = s_{-i}$).

[20] We discuss some of these other factors in the conclusion. We simply note here that if, for example, the upstream firms are better informed about the demand for their goods than the downstream firms, or if creating incentives for upstream innovation are important, then delegating pricing control to the upstream firms might make sense for the downstream firms even if competitive pressures are stronger upstream.

firms' decisions. One might therefore expect the agency model to be adopted in our setting when it would lead to higher retail prices (and hence higher industry profit), but not when it would lead to lower retail prices. As we will now show, however, this intuition is incorrect.

For there to be an equilibrium in which none or both downstream firms adopt the agency model, it must be that no firm would unilaterally want to deviate to a mixed regime in which only one firm delegates retail pricing. Before proceeding, therefore, it is useful to characterize what must be true of equilibrium prices if a mixed regime were to occur.

Without loss of generality, we consider the mixed regime in which only D_i adopts the agency model. In this case, D_{-i} decides p^1_{-i} and p^2_{-i}, U^1 decides p^1_i, and U^2 decides p^2_i. We assume that all prices are chosen simultaneously. The maximization problems are thus

$$\max_{p^1_i} \ \Pi^{U1}, \ \ \max_{p^2_i} \ \Pi^{U2}, \tag{11}$$

and

$$\max_{p^1_{-i}, p^2_{-i}} \ \Pi_{D_{-i}}. \tag{12}$$

From (11) and (12), we obtain the system of first-order conditions that must be satisfied in equilibrium. The two conditions that arise from D_{-i}'s problem are analogous to those already given in (4) and (5). The two conditions that arise from U^1 and U^2's problem are analogous to those already given in (7) and (8). Our assumptions imply that an equilibrium in this mixed regime exists and is unique (and therefore that these conditions are sufficient).

The assumed symmetry between goods and between firms implies that if U^1 and U^2's prices are such that $p^1_i = p^2_i$, then D_{-i} would set $p^1_{-i} = p^2_{-i}$, and vice versa. Thus, it follows that the retail prices at each downstream firm will be the same in equilibrium. This in turn implies that the four conditions that characterize the unique equilibrium in this regime can be reduced to just two conditions, one that determines p^j_i and one that determines p^j_{-i}.

$$(1 - s_i)\left(p^j_i \frac{\partial q^j_i(\mathbf{p})}{\partial p^j_i} + q^j_i(\mathbf{p})\right) + (1 - s_{-i})\left(p^j_{-i} \frac{\partial q^j_{-i}(\mathbf{p})}{\partial p^j_i}\right) \ = \ 0. \tag{13}$$

$$p^j_{-i} \frac{\partial q^j_{-i}(\mathbf{p})}{\partial p^j_{-i}} + q^j_{-i}(\mathbf{p}) + p^j_{-i} \frac{\partial q^{-j}_{-i}(\mathbf{p})}{\partial p^j_{-i}} \ = \ 0, \tag{14}$$

Here we see that although the solution to (14) is independent of s_i and s_{-i}, the solution to (13) is not, unless $s_i = s_{-i}$. It follows therefore that unless $s_i = s_{-i}$, the equilibrium retail prices in this case will depend on both s_i and s_{-i}, just as we found for the case in which both firms adopt the agency model. Moreover, the comparative statics are similar.[21]

We are now able to compare equilibrium prices across the different cases and regimes. Let p_1^{a*}, p_2^{a*} denote the unique pair of prices that solves (13) and (14) when $i = 1$, and define $\mathbf{p^{a*}} \equiv (p_1^{a*}, p_1^{a*}, p_2^{a*}, p_2^{a*})$ to be the corresponding vector of equilibrium prices in the mixed regime in which only D_1 has the agency model.[22] Then, recalling that $p = p^{**}$ solves (9) and $p = p^{aa}$ solves (10) when $s_i = s_{-i}$, we can rank the equilibrium prices as follows:

Lemma 3 *When $s_i = s_{-i}$, equilibrium retail prices are such that*

- $p^{aa} = p_1^{a*} = p_2^{a*} = p^{**}$ if $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} = \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$;
- $p^{aa} < p_1^{a*} < p_2^{a*} < p^{**}$ if $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} < \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$;
- $p^{aa} > p_1^{a*} > p_2^{a*} > p^{**}$ if $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$.

Lemma 3 implies that the equilibrium prices in the mixed regimes will be bounded on one side by the equilibrium prices that arise when both firms adopt the agency model and on the other side by the equilibrium prices that arise when neither firm adopts the agency model. Equilibrium retail prices in the mixed regimes will be lower than when both firms delegate, and higher than when neither firm delegates, for instance, if the degree of substitution between downstream firms exceeds the degree of substitution between goods.[23]

The intuition for this result can best be seen by looking at Figure 1, where the price at downstream firm 1 is on the horizontal axis, and the price at downstream firm 2 is on the vertical axis. Per Lemma 3, we have assumed that $s_1 = s_2$, and we have assumed that the substitution between downstream firms is greater than the substitution between goods.[24] In this figure, $BR_2^*(p_1^j)$ represents the locus of prices p_2^j that satisfy (14) if downstream firm 2 does not adopt the agency model, and $BR_1^*(p_2^j)$ represents the corresponding the locus of prices p_1^j for downstream firm 1. The intersection of these best-reply curves occurs at the price pair (p^{**}, p^{**}), where $p = p^{**}$ is the unique price in the no-delegation case. Similarly, $BR_1^a(p_2^j)$ represents the locus of prices p_1^j that satisfy (13) when downstream firm

[21] We show in the Appendix that p_i^j, p_{-i}^j, and $p_i^j - p_{-i}^j$ will be increasing in s_i and decreasing in s_{-i}.
[22] Note that p_i^{a*} depends on s_1 and s_2. The arguments have been suppressed for ease of exposition.
[23] Analogous relationships hold for the mixed regime in which only D_2 adopts the agency model.
[24] Analogous intuition holds for the setting in which the degree of substitution is greater upstream.

1 adopts the agency model, and $BR_2^a(p_1^j)$ represents the corresponding locus of prices p_2^j for downstream firm 2. The intersection of these best-reply curves occurs at the price pair (p^{aa}, p^{aa}), where $p = p^{aa}$ is the unique price in the delegation case (both downstream firms adopt the agency model). For the regime in which only D_1 delegates retail pricing, the solution occurs at the price pair (p_1^{a*}, p_2^{a*}), which is where the best-reply curve $BR_2^*(p_1^j)$ intersects $BR_1^a(p_2^j)$ (here, prices p_1^{a*} and p_2^{a*} correspond to the unique pair of prices that solves (13) and (14) when only D_1 adopts the agency model). In this case, U^1 and U^2 charge the same price p_1^{a*} on D_1's two products, and D_2 sets a common price p_2^{a*} on its two products. Lemma 3 then follows in this setting because, as can be seen, $p^{aa} > p_i^{a*} > p^{**}$.

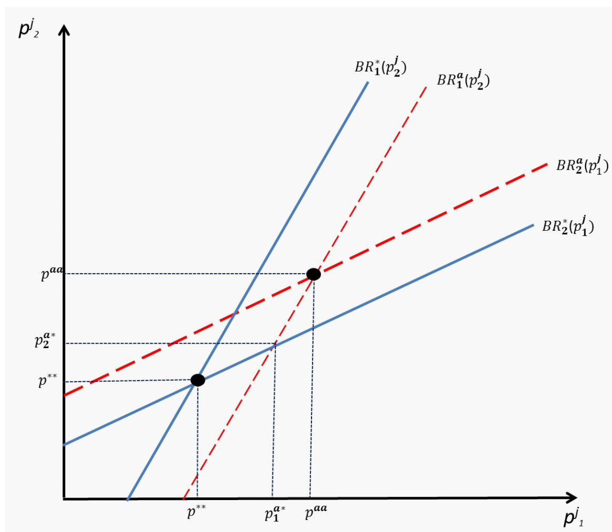

Figure 1

When s_1 is not equal to s_2, prices in the mixed regimes (and also in the case where both firms adopt the agency model) will be affected. Nevertheless, we would expect them to continue to be bounded by the equilibrium prices in the no-delegation case on the one hand and the prices that would arise in equilibrium in the case where both firms adopt the agency model on the other hand, as long as s_1 and s_2 are not too far apart. For our next result, therefore, we only require that s_1 and s_2 be sufficiently close together that the rank orderings in Lemma 3 are unchanged, and we assume without loss of generality that if only one downstream firm adopts the agency model, it will be D_1. We also define p_1^{aa} and p_2^{aa} to be the unique pair of prices that solve (7) and 8), given that $p_i^j = p_i^{-j}$, and note that the corresponding vector of equilibrium prices in this regime is $\mathbf{p}^{aa} \equiv (p_1^{aa}, p_1^{aa}, p_2^{aa}, p_2^{aa})$. It thus follows from Lemma 2 that $p_1^{aa} = p_2^{aa} = p^{aa}$ if $s_1 = s_2$ and that $p_i^{aa} > p_{-i}^{aa}$ if $s_i > s_{-i}$.

The following proposition describes what can be said in general:

Proposition 2 *Suppose there is an initial stage of the game in which the downstream firms simultaneously and independently choose whether to adopt the agency model. Then,*[25]

- *if the equilibrium retail prices in the various subgames are such that $p_i^{aa} < p_i^{a*} < p^{**}$, the unique equilibrium outcome is for neither firm to adopt the agency model;*

- *if the equilibrium retail prices in the various subgames are such that $p_i^{aa} > p_i^{a*} > p^{**}$, there are settings in which each outcome can arise in equilibrium. The outcome need not be unique, and there may be no equilibrium in which the agency model is adopted.*

To prove the first bullet point, note that if the unique equilibrium outcome is for neither firm to adopt the agency model, then it must be that neither firm unilaterally wants to delegate control over its retail prices to the upstream firms. Or, in other words, it must be that $\Pi_{D1}(\mathbf{p}^{**}) \geq \Pi_{D1}(\mathbf{p}^{\mathbf{a}*})$ and $\Pi_{D2}(\mathbf{p}^{**}) \geq \Pi_{D2}(\mathbf{p}^{*\mathbf{a}})$. This is indeed the case, as we can see by forming the difference for D_1 (analogously for D_2) and making a simple substitution:

$$\begin{aligned}\Pi_{D1}(\mathbf{p}^{**}) - \Pi_{D1}(\mathbf{p}^{\mathbf{a}*}) &= 2s_1\left(p^{**}q_1^1(p^{**},p^{**},p^{**},p^{**}) - p_1^{a*}q_1^1(p_1^{a*},p_1^{a*},p_2^{a*},p_2^{a*})\right) \\ &\geq 2s_1\left(p^{**}q_1^1(p^{**},p^{**},p^{**},p^{**}) - p_1^{a*}q_1^1(p_1^{a*},p_1^{a*},p^{**},p^{**})\right) \\ &> 0.\end{aligned} \tag{15}$$

The first inequality in (15) follows because D_1 and D_2 are substitutes and retail prices in this case are highest in the subgame where neither firm adopts the agency model. The last inequality follows because $p_1^1 = p_1^2 = p^{**}$ maximizes D_1's profit when D_2 sets $p_2^1 = p_2^2 = p^{**}$.

No other outcome can arise in this case because to support a mixed regime in which only D_1 adopts the agency model, it must be that $\Pi_{D1}(p^{a*}) \geq \Pi_{D1}(p^{**})$ — which we have just shown fails to hold. And, to support an outcome in which both D_1 and D_2 adopt the agency model, it must be that $\Pi_{D1}(p^{aa}) \geq \Pi_{D1}(p^{*a})$ and $\Pi_{D2}(p^{aa}) \geq \Pi_{D2}(p^{a*})$ — which we can show must also fail to hold using reasoning similar to the reasoning from above.[26]

We prove the second bullet point in the Appendix, but note here that when prices are such that $p_i^{aa} > p_i^{a*} > p^{**}$, one might conjecture that both firms would always adopt the

[25] If $s_1 = s_2$, then, per Proposition 1 and Lemma 3, a necessary and sufficient condition for the first bullet point to hold is that the degree of substitution must be greater upstream, and a necessary and sufficient condition for the second bullet point to hold is that the degree of substitution must be greater downstream.

[26] Note that $\Pi_{D1}(\mathbf{p}^{\mathbf{aa}}) - \Pi_{D1}(\mathbf{p}^{*\mathbf{a}})$ is less than or equal to $\Pi_{D1}(p_1^{aa},p_1^{aa},p_2^{*a},p_2^{*a}) - \Pi_{D1}(p_1^{*a},p_1^{*a},p_2^{*a},p_2^{*a})$, which is less than zero because $p_1^1 = p_1^2 = p_1^{*a}$ maximizes D_1's profit when its rival sets $p_2^1 = p_2^2 = p_2^{*a}$.

agency model. This is not true. Proposition 2 implies that there may be equilibria in which neither firm adopts the agency model, and there may be no equilibrium in which the agency model is adopted. The reason is that neither firm may want to be the only one to adopt the agency model. We can see from (15), for example, that if $p_i^{aa} > p_i^{a*} > p^{**}$, the first inequality would be reversed, but the second inequality would still hold. This would imply that a downstream firm's gain from being the only one to adopt the agency model would be greater than some amount which is negative — which does not tell us much.

It turns out that there are settings in which all three outcomes — zero, one, or both firms adopting the agency model — can arise in equilibrium in this case. We label the pricing equilibria that correspond to these outcomes as points A, B, and C, respectively, in Figure 2 below. Under some conditions, the outcome depicted in point A, where neither firm adopts the agency model, may be the only outcome that can arise in equilibrium.

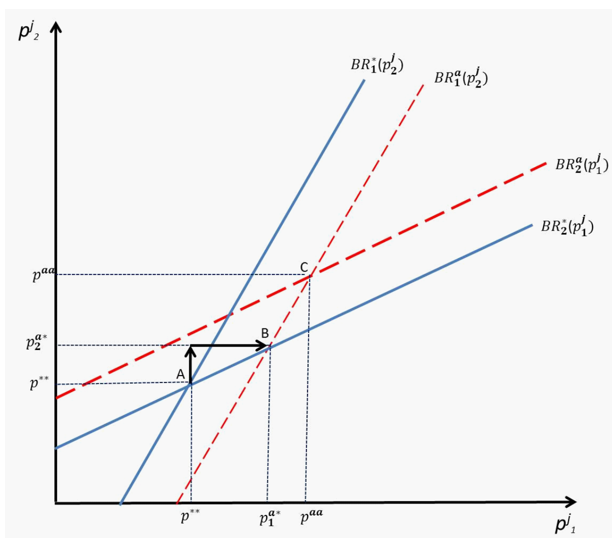

Figure 2

This last result can be understood intuitively by noting that there are countervailing forces to consider when a downstream firm, say D_1, is deciding whether to adopt the agency model. On the one hand, by adopting the agency model, D_1 can induce the retail prices at D_2 to increase (which positively impacts D_1's profit because D_1 and D_2 are substitutes). This is depicted by the up arrow in Figure 2 for the case in which only D_1 adopts the agency model. On the other hand, by adopting the agency model, D_1's prices will be chosen to maximize a different objective function than what D_1 would have maximized. This hurts D_1 because, as can seen, U^1 and U^2's chosen prices will be too high (i.e., greater than

$BR_1^*(p_2^j)$) in the sense that they will be higher than what D_1 would have chosen for the same p_2^j if instead it had retained control. This is depicted by the right arrow in Figure 2.

Whether the former effect (a higher induced p_2^j) will be viewed as outweighing the latter effect (a price p_1^j that is too high given D_2's price p_2^j), and thus whether D_1 will find the tradeoff to be worth making depends on demand. Nevertheless, some intuition is possible. The greater would be the induced increase in p_2^j, the more likely it is that D_1 unilaterally will want to adopt the agency model (or refrain from dropping it) all else being equal.

Consider, for example, the case in which the upstream goods are independent (no upstream substitution). Delegating pricing upstream in this case leads to monopoly pricing on both goods, and industry profit is maximized. If the substitution between platforms is high, the induced increase in prices that arises when both firms adopt the agency model will be high, and neither firm will want to deviate.[27] But if the substitution between platforms is low, so that the downstream firms would also set relatively high prices if instead they retained control of the pricing, the induced increase in prices that arises when both firms adopt the agency model will be low, and deviating may then be profitable. Indeed, as we show in the proof of Proposition 2, the unique outcome in this case (no upstream substitution, low downstream substitution) may be for no firm to adopt the agency model.

2.3 What is the role of MFN clauses?

We have shown that the agency model might not be adopted by the platforms even when industry-wide adoption would unambiguously increase retail prices and profits. We now show that MFN clauses may be used to nudge the industry toward adoption in these cases.

We model an MFN clause, when imposed by D_i, as requiring that U^j set $p_i^j \leq p_{-i}^j$ whether or not it also controls p_{-i}^j. To analyze this, we continue to assume that all prices are set simultaneously, and to account for the possibility that D_{-i} might set lower retail prices than U^j anticipates, we further assume that p_i^j will adjust automatically to satisfy the MFN clause in the (out-of-equilibrium) event that the constraints fail to hold initially.

Whether D_i's MFN clause will have any effect on U^j's choices in this setting will depend, of course, on whether it would be binding in equilibrium. It need not be. Even without

[27] One might expect to the contrary that the temptation to deviate from the agency model would be particularly strong if downstream substitutability is very high, with a strong business-stealing effect. The reason this intuition fails to hold is because the deviation can be observed prior to the setting of prices.

an MFN clause, D_i's prices might be lower than D_{-i}'s prices if, for example, $s_i \leq s_{-i}$ and substitution is greater upstream than downstream. In other settings, however, the MFN clause would be binding (e.g., if $s_i \geq s_{-i}$ and substitution is instead greater downstream).

To see what prices can be supported in equilibrium when D_i's MFN clause is binding, consider first the case of a mixed regime in which only D_i adopts the agency model (D_{-i} retains control over its pricing). Note first that because of D_i's MFN clause, D_{-i} cannot undercut U^j's retail prices. Any attempt to do so would only force U^j to follow suit with its own price cut. Such a strategy would therefore be profitable for D_{-i} only for retail prices that were above the industry profit-maximizing price, which we denote by $p = p^I$.

Note next that for any price $p_{-i}^j = \hat{p}$ set by D_{-i} such that the left-hand-side of (13) would be negative when evaluated at $p_i^j = \hat{p}$ (i.e., when the best reply of U^j is to set $p_i^j < \hat{p}$ when all other prices are equal to $\hat{p}$), the upstream firms would want to undercut D_{-i}'s price and would be free to do so. Note finally that for any price $p_{-i}^j = \hat{p}$ set by D_{-i} such that the left-hand-side of (13) would be positive when evaluated at $p_i^j = \hat{p}$ (i.e., when the best reply of U^j is to set $p_i^j > \hat{p}$ when all other prices are equal to $\hat{p}$), the upstream firms would ideally want to charge higher retail prices but would be forced by D_i's MFN clause to match D_{-i}'s lower price. It follows that if $p = p^m$ denotes the retail price that solves (13) when all retail prices are the same (note that p^m is a function of s_1 and s_2; when $s_i = s_{-i}$, then $p^m = p^{aa}$, and when $s_i > s_{-i}$, then $p^m > p_i^{aa} > p_{-i}^{aa}$), then the smaller of p^I and p^m is the highest retail price that can be supported in equilibrium with MFN clauses.

Other prices, however, can also be supported. For example, equal prices in the neighborhood below p^m can also be supported when $p^m \leq p^I$ because at these prices, the upstream firms would ideally like to set higher retail prices but are constrained by D_i's MFN clause, and D_{-i} will not find it profitable to deviate because although it would ideally like to set lower retail prices, this would only cause the upstream firms to reduce their prices as well.

The following lemma describes what can be said in general:

Lemma 4 *In the mixed regime in which only D_i adopts the agency model and has an MFN clause that prohibits U_1 and U_2 from setting higher prices at D_i than are set at D_{-i},*

- *D_i's MFN clause will have no effect on prices if $s_i \leq s_{-i}$ and $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} < \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$;*
- *D_i's MFN clause will have an effect on prices if $s_i \geq s_{-i}$ and $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$. In*

this case, the retail prices that arise in equilibrium will be the same for both downstream firms, and any price $p \in [p^{**}, min\{p^m, p^I\}]$ can be supported in equilibrium.

There are multiple equilibria in this regime because when D_i's MFN clause binds, a kink point is created in the best replies of the upstream firms and D_{-i}. The upstream firms cannot set higher prices than D_{-i} sets, and D_{-i} knows this. The clause thus works to mitigate D_{-i}'s incentive to set low prices. At the same time, however, if D_{-i} anticipates that the upstream firms will set relatively low prices, then it may be optimal for D_{-i} also to set relatively low prices, and the relatively low prices may then become self-supporting.

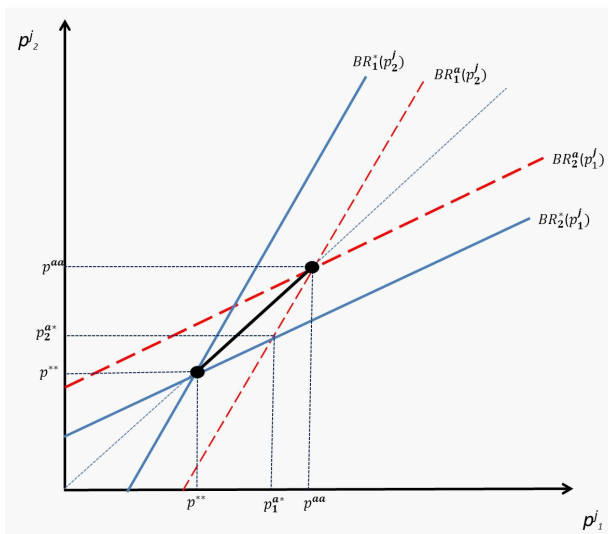

Figure 3

Figure 3 illustrates the equilibrium outcomes for the mixed regime in which only D_i adopts the agency model, $s_i = s_{-i}$, and substitution is greater downstream than upstream. The black boldface line illustrates the multiple equilibria from the second bullet in Lemma 4. At the lower bound of what can be supported when D_i has an MFN clause, retail prices are at (p^*, p^*), the same as if D_i had not adopted the agency model. In all other outcomes, however, retail prices are strictly higher. The same is true when $s_i > s_{-i}$ and the degree of substitution is greater downstream. It follows, therefore, that adopting the agency model and having an MFN clause in this case is a best response for D_i (it is a strict best response for all but the least advantageous outcome) when D_{-i} does not adopt the agency model.

This leads to our first main result of this subsection. At least one firm will adopt the agency model when Pareto optimality is used to select among equilibria, provided that conditions are such that industry-wide adoption would increase retail prices and industry profits. This follows because $p = min\{p^m, p^I\} > p^{**}$ in the Pareto-optimal equilibrium of the mixed regime in which only D_i adopts the agency model and D_i has an MFN clause.

We can further extend our results by noting that the pricing outcome is unique when both downstream firms adopt the agency model and at least one firm has an MFN clause. The reason is that the upstream firms then control the retail prices of their goods at both locations and thus can satisfy their MFN clause(s) without having to anticipate the prices of an independent retailer. In these settings, if only D_i has an MFN clause, then U^j will choose p_i^j and p_{-i}^j to maximize its profit subject to $p_i^j \leq p_{-i}^j$. And if both D_i and D_{-i} have MFN clauses, then U^j will choose p_i^j and p_{-i}^j to maximize its profit subject to $p_i^j = p_{-i}^j$.

When the constraints imposed by the MFN clause(s) are binding, the first-order conditions, $j = 1, 2$, that characterize the Bertrand equilibrium when both downstream firms adopt the agency model and at least one firm has an MFN clause can be written as

$$\frac{\partial \Pi^{Uj}}{\partial p_i^j}\Big|_{p_{-i}^j = p_i^j} = (1 - s_i)\left(p_i^j\left(\frac{\partial q_i^j}{\partial p_i^j} + \frac{\partial q_i^j}{\partial p_{-i}^j}\right) + q_i^j\right) + (1 - s_{-i})\left(p_i^j\left(\frac{\partial q_{-i}^j}{\partial p_i^j} + \frac{\partial q_{-i}^j}{\partial p_{-i}^j}\right) + q_{-i}^j\right) = 0. \tag{16}$$

Solving these conditions to obtain the equilibrium p_i^j and p_i^{-j} yields a surprising implication. If U^{-j} is setting $p_i^{-j} = p_{-i}^{-j} = p^{aa}$, then the best U^j can do is also to set $p_i^j = p_{-i}^j = p^{aa}$ (recall that p^{aa} is the price that solves (10)), and vice versa. This suggests that when the MFN clause(s) are binding (as they will be if both D_i and D_{-i} have MFN clauses, or if only D_i has an MFN clause and $s_i \geq s_{-i}$), the upstream firms lose their ability to disadvantage a downstream firm that has a higher revenue share. Thus, unlike in the delegation case without MFN clauses, with binding MFN clauses, the unique outcome when both firms adopt the agency model calls for all prices to equal p^{aa}, whether or not s_i is equal to s_{-i}.

This leads to our second main result of this subsection. In any equilibrium in which at least one downstream firm adopts the agency model and has a binding MFN clause, retail prices on all products will be at least as high as p^{aa}. This result does not depend on whether Pareto optimality is used to select among equilibria in the subgames with MFN clauses. It holds because if D_i adopts the agency model and imposes an MFN clause, then D_{-i} can ensure that the unique equilibrium price vector in the continuation game will be $\mathbf{p} = (p^{aa}, p^{aa}, p^{aa}, p^{aa})$ by also adopting the agency model and having an MFN clause.

It remains to consider whether and under what conditions equilibria exist in which at least one firm adopts the agency model and has a binding MFN clause. The following proposition summarizes our results thus far and describes what can be said in general:

Proposition 3 *Suppose the downstream firms can simultaneously and independently choose whether to delegate retail pricing (adopt the agency model) and have an MFN clause. Then, if the substitution between downstream firms is greater than the substitution between goods,*

- *there exists an equilibrium in which at least one firm adopts the agency model and has an MFN clause. In every such equilibrium, retail prices are the same and equal to p^{aa} when $s_i = s_{-i}$, and the same and greater than or equal to p^{aa} when $s_i > s_{-i}$;*
- *there exists an equilibrium in which D_i adopts the agency model and has an MFN clause, and retail prices are the same and strictly exceed $\max\{p_i^{aa}, p^{aa}\}$ when $s_i > s_{-i}$;*
- *there does not exist an equilibrium in which neither firm adopts the agency model if Pareto optimality is used to select among equilibria in the mixed-regime subgames.*

It follows from Proposition 3 that MFN clauses can have significant effects when they are binding. If, for example, substitution is greater downstream, and Pareto optimality is used to select among equilibria in the mixed regimes in which only one firm adopts the agency model and has an MFN clause, then there is no equilibrium in which neither firm adopts the agency model. Not adopting the agency model when the rival firm does not adopt the agency model ensures that equilibrium prices in the continuation game will be p^{**}, whereas by adopting the agency model and imposing an MFN clause, a deviating firm can ensure that equilibrium prices in the continuation game will be higher. An MFN clause can thus ensure that at least one firm will find it profitable to adopt the agency model.

We can also see from Proposition 3 that MFN clauses can affect equilibrium prices. This occurs in some well-defined settings. When $s_i = s_{-i}$ and the degree of substitution is greater downstream, it occurs when the equilibrium in the absence of MFN clauses is for either zero or one firms to adopt the agency model. In the first instance, retail prices in the continuation game are given by $\mathbf{p} = (p^{**}, p^{**}, p^{**}, p^{**})$, and in the second instance, they are given by $\mathbf{p} = (p_1^{a*}, p_1^{a*}, p_2^{a*}, p_2^{a*})$ if only D_1 adopts the agency model. In both instances, the retail prices are strictly less than p^{aa} (see Lemma 3). It follows from Proposition 3, therefore, that MFN clauses would lead to strictly higher retail prices in these settings.

MFN clauses can also lead to higher retail prices when $s_i > s_{-i}$ and the degree of substitution is relatively greater downstream. In this setting, we know from Proposition 3 that an equilibrium in which D_i adopts the agency model and has an MFN clause exists, and that retail prices on all products in this equilibrium are the same and strictly greater than $\max\{p_i^{aa}, p^{aa}\}$. For example, using Pareto optimality to select from among equilibria in the mixed regimes, it is straightforward to show that such an equilibrium exists and that the equilibrium retail prices in this case are equal to $min\{p^m, p^I\} > \max\{p_i^{aa}, p^{aa}\}$. The conclusion that MFN clauses can lead to higher retail prices in this case then follows on noting that $\max\{p_i^{aa}, p^{aa}\}$ is the maximum price that can arise in equilibrium otherwise.

2.4 Revenue-sharing splits

We have thus far assumed that s_1 and s_2 are exogenous. This has simplified things because it has allowed us to focus on our three questions of interest (namely, (i) when will the agency model lead to higher prices, (ii) when will the agency model be adopted, and (iii) what is the role of MFN clauses) without worrying about whether the firms' revenue shares might depend on the choices made. More importantly, however, our assumption that s_1 and s_2 can be taken as exogenous (or, equivalently, determined prior to the downstream firms' delegation decisions) accords with what we have observed in practice. When Apple was entering the market for apps, for example, and deciding whether to adopt the agency model, it employed the same 70/30 revenue-sharing split it was using for music. Similarly, when Apple was entering the market for e-books and deciding whether to adopt the agency model, it took the same 70/30 revenue-sharing split it was using for music (where it did not delegate its pricing) and apps (where it did delegate its pricing) and imposed it on the book publishers. When they resisted and tried to obtain better terms, Apple cited its 70/30 revenue-sharing split in both music and apps as a precedent and refused to give in.[28]

One can, of course, make s_1 and s_2 endogenous by allowing the downstream firms to choose what revenue-sharing splits to offer. In this case, in principle, we would expect the downstream firms to take into account some of the factors we have been considering (e.g., that the upstream firms may be incentivized to disadvantage a downstream firm

[28] This is evident in the judge's decision in the recent e-books case (see footnote 3). For example, after noting that HarperCollins, a large book publisher, suggested that Apple take a 20% (rather than a 30%) commission, the judge wrote (p. 58) "Apple refused to budge. This was the same commission it charged in the App Store ... The 30% commission was ultimately adopted across all of Apple's final Agreements.".

that has a higher revenue share than its rival). However, we would also expect their choices to depend in practice on factors that are outside of the model (such as the need to encourage innovation).[29] It follows that while adding a stage to our model — with its built-in symmetry — might allow us to predict that the revenue-shares will be the same for both platforms, it would not allow us to assess the magnitudes of the splits with confidence.

Nevertheless, we can offer a few insights. First, even abstracting from any fixed costs, we would not expect the upstream firms to be left with zero surplus (despite the downstream firms having all the bargaining power). If one downstream firm were offering a split of 0/100, the rival downstream firm could profitably deviate by offering the upstream firms a small positive share, thereby inducing them to stop supplying its rival (no content provider would supply a platform that was offering nothing if it took away sales from a platform that was offering something). This implies that the upstream firms must earn positive surplus.

Second, we would expect the upstream firms' surplus to be increasing in the substitution between platforms. It follows from Lemma 2 and the expressions in (13) and (14) that if at least one firm adopts the agency model, a downstream firm that tries to keep a larger revenue share for itself will be disadvantaged (an increase in s_i will cause U^j to modify its prices so as to stimulate sales through D_{-i} relative to D_i). Faced with a rival platform that was offering a 70/30 split, a platform that offered only a 65/35 split, for example, would have to be concerned not only about possibly being foreclosed from the market entirely, but also about being partially foreclosed from the market, in the sense that its expected sales would be less than they would have been if its revenue split had also been 70/30.[30]

Third, as mentioned above, we have abstracted from the need to encourage innovation, and taken the number and quality of the upstream firms' goods as given. In practice, however, content providers must have some expectation of reward if they are to invest their time, energy, and know-how into creating quality products that have value for consumers. Moreover, the creation of content is inherently uncertain and not without risk. For these

[29] The need to encourage innovation may help to explain why the revenue splits in practice are 70/30 (in favor of the upstream firms) as opposed to, for example, 30/70 (in favor of the downstream firms).

[30] A platform may be able to mitigate this tradeoff by having an MFN clause in its contract. This would allow it to keep a larger share of the revenue for itself without having to worry about being partially foreclosed. However, an MFN clause in combination with a higher revenue share would not prevent content providers from refusing to supply the platform, and it may have the effect of discouraging innovation, which the platform may not want to do. In contrast, our focus has been on showing that MFN clauses can play an important role even if they have no effect on the revenue-sharing splits. Furthermore, as we emphasized above, Apple's motivation for adopting MFN clauses in the e-books market does not seem to have been to increase its share of the pie (they used the same 70/30 split for e-books as they did for music and apps).

reasons, we would expect both the number and quality of the upstream innovations to be increasing in the share of the revenue the upstream firms receive (assuming, as seems realistic, that investment decisions are made after the revenue-sharing splits are determined). Once again there would be pros and cons of offering a 65/35 split versus a 70/30 split.

The trade-off facing the platforms in each instance is thus a familiar one: is it better to have a larger share of a smaller profit pie, or a smaller share of a larger profit pie? We would expect the revenue shares that arise in equilibrium to account for these tensions.

3 Conclusion

This paper has analyzed the competitive effects of the agency model in a market structure with both upstream and downstream competition and interlocking relationships. We found that the agency model can lead to higher or lower prices for consumers depending in part on whether the revenue-sharing splits of the downstream platforms are the same or different, and on whether the substitution is greater between goods or between platforms. We also found that even if industry-wide adoption of the agency model would lead to higher retail prices and profits for all firms, there may be equilibria in which it is not universally adopted, or in which it is not even adopted at all. There is thus a prisoner's dilemma aspect to agency model adoption. Lastly, we found that MFN clauses can be used in such settings to induce rival platform providers both to adopt the agency model and to set higher retail prices.

It should be noted that in deriving our results, we have, in addition to taking the number and quality of the upstream goods as given, also abstracted from issues of asymmetric information and uncertainty in our analysis. In doing so, we have kept the focus on the firms' pricing decisions and how these decisions would be expected to impact the adoption of the agency model all else being equal. We recognize, however, that it can only provide a partial depiction of the complex forces that typically govern relationships in these markets.

Our analysis thus complements existing literature, which focuses on some of these other forces, albeit at the expense of some of the forces that we consider. Many of the papers in this literature suggest other motivations for why the agency model might be adopted. For example, it has been noted that the upstream content providers may be better informed than the downstream platform providers about the market potential for their goods. In such cases, one might expect there to be efficiency gains from letting the content providers determine the retail prices (see Foros, Kind and Hagen, 2009). Hagiu and Wright (2013) analyze the efficient choice of business format when firms engage in non-contractible marketing activities (however, they abstract from pricing issues and do not focus on the agency model per se). Gans (2012) considers the hold-up problem that may arise if consumers must undertake specific investments in order to have platform access prior to the upstream firms' choosing prices. In the market for e-books, it has been suggested that there may be a negative externality from e-books to printed books (see Abhiskek et al., 2012). Letting the publishers decide on the retail prices allows them to internalize this negative externality.

Other authors, however, point to externalities that may work against transferring retail pricing control to the upstream content providers. Content in the form of music, apps and e-books, for example, are complementary products to tablets and smartphones. Such complementarities would, all else being equal, work in favor of retail prices being determined by the platform providers (see Gaudin and White, 2013, for a discussion of these issues).

In short, there are likely to be many forces that affect the adoption of the agency model in practice, and more work is surely needed to understand their effects. Within this broader context, our contribution to the extant literature is to highlight the role played by MFN clauses in the firms' adoption decisions, and to emphasize, among other things, the importance of the relative substitution patterns between goods and between platforms.

Appendix

Proof of Lemma 2: The conclusion that all prices will be the same when the downstream firms control prices follows from the fact that the firms and the goods are symmetrically differentiated, and noting that the solution to (4), (5), and their analogs does not depend on revenue shares. The first bullet point follows from the fact that since the goods are symmetrically differentiated, each upstream firm will set the same retail price for D_i. The second bullet point follows from the fact that since the downstream firms are symmetrically differentiated, each upstream firm will set $p_i^j = p_{-i}^j$ when $s_i = s_{-i}$. The third bullet point follows from the first two bullet points and the fact that $p_i^j - p_{-i}^j$ is increasing in s_i.

It remains only to show that $p_i^j - p_{-i}^j$ is increasing in s_i. To see that this holds, note that because the goods are symmetrically differentiated, each upstream firm will set the same retail price for D_i in equilibrium. This means that $p_1^j = p_1^{-j}$ and $p_2^j = p_2^{-j}$. Therefore, let p_1 denote the common price at retailer 1 and p_2 denote the common price at retailer 2. The four first-order conditions that characterize the Bertrand equilibrium in the agency model (i.e., (7) and (8), $j = 1, 2$) can therefore be reduced to the following two conditions:

$$(1 - s_1)\left(p_1 \frac{\partial q_1^1}{\partial p_1^1} + q_1^1\right) + (1 - s_2)\left(p_2 \frac{\partial q_2^1}{\partial p_1^1}\right) \;=\; 0, \tag{A.1}$$

$$(1 - s_1)\left(p_1 \frac{\partial q_1^1}{\partial p_2^1}\right) + (1 - s_2)\left(p_2 \frac{\partial q_2^1}{\partial p_2^1} + q_2^1\right) \;=\; 0. \tag{A.2}$$

We can define best-reply curves as follows. Let $p_1 = BR_1^a(p_2, s_1, s_2)$ be the solution to (A.1) and $p_2 = BR_2^a(p_1, s_1, s_2)$ be the solution to (A.2). Then, it must be that in equilibrium, retail prices satisfy $p_1 = BR_1^a(BR_2^a(p_1, s_1, s_2), s_1, s_2)$ and $p_2 = BR_2^a(BR_1^a(p_2, s_1, s_2), s_1, s_2)$.

Consider first the equilibrium p_1. Taking the derivative with respect to s_2 yields

$$\frac{\partial p_1}{\partial s_2} \;=\; \frac{\partial BR_1^a}{\partial p_2}\left(\frac{\partial BR_2^a}{\partial p_1}\frac{\partial p_1}{\partial s_2} + \frac{\partial BR_2^a}{\partial s_2}\right) + \frac{\partial BR_1^a}{\partial s_2}. \tag{A.3}$$

Rearranging this yields

$$\frac{\partial p_1}{\partial s_2} \;=\; \frac{\frac{\partial BR_1^a}{\partial p_2}\frac{\partial BR_2^a}{\partial s_2} + \frac{\partial BR_1^a}{\partial s_2}}{(1 - \frac{\partial BR_1^a}{\partial p_2}\frac{\partial BR_2^a}{\partial p_1})}. \tag{A.4}$$

Now consider the equilibrium p_2. Taking the derivative with respect to s_2 yields

$$\frac{\partial p_2}{ds_2} \;=\; \frac{\partial BR_2^a}{\partial p_1}\left(\frac{\partial BR_1^a}{\partial p_2}\frac{\partial p_2}{\partial s_2} + \frac{\partial BR_1^a}{\partial s_2}\right) + \frac{\partial BR_2^a}{\partial s_2}. \tag{A.5}$$

Rearranging this yields

$$\frac{\partial p_2}{\partial s_2} = \frac{\frac{\partial BR_2^a}{\partial p_1}\frac{\partial BR_1^a}{\partial s_2} + \frac{\partial BR_2^a}{\partial s_2}}{(1 - \frac{\partial BR_2^a}{\partial p_1}\frac{\partial BR_1^a}{\partial p_2})}. \tag{A.6}$$

Using (A.6) and (A.4), we note that the sign of $\frac{\partial p_2}{\partial s_2} - \frac{\partial p_1}{\partial s_2}$ is the same as the sign of

$$\frac{\partial BR_2^a}{\partial p_1}\frac{\partial BR_1^a}{\partial s_2} + \frac{\partial BR_2^a}{\partial s_2} - \left(\frac{\partial BR_1^a}{\partial p_2}\frac{\partial BR_2^a}{\partial s_2} + \frac{\partial BR_1^a}{\partial s_2}\right), \tag{A.7}$$

which can be rewritten as

$$\left(1 - \frac{\partial BR_1^a}{\partial p_2}\right)\frac{\partial BR_2^a}{\partial s_2} - \left(1 - \frac{\partial BR_2^a}{\partial p_1}\right)\frac{\partial BR_1^a}{\partial s_2}. \tag{A.8}$$

Using the fact that $|\frac{\partial BR_1^a}{\partial p_2}| < 1$, $|\frac{\partial BR_2^a}{\partial p_1}| < 1$, $\frac{\partial BR_2^a}{\partial s_2} > 0$, and $\frac{\partial BR_1^a}{\partial s_2} < 0$, it then follows that the sign of (A.8) is positive. This establishes that $p_i^j - p_{-i}^j$ is increasing in s_i. **Q.E.D.**

Proof of Proposition 1: We have shown in the text that in the no-RPM case, conditions (4), (5), and their analogs imply that in equilibrium, the unique price p will satisfy

$$p\frac{\partial q_i^j(\mathbf{p})}{\partial p_i^j} + q_i^j(\mathbf{p}) + p\frac{\partial q_i^{-j}(\mathbf{p})}{\partial p_i^j} = 0, \tag{A.9}$$

whereas when both firms adopt the agency model and revenue shares are the same, conditions (7), (8), and their analogs imply that in equilibrium, the unique price p will satisfy

$$p\frac{\partial q_i^j(\mathbf{p})}{\partial p_i^j} + q_i^j(\mathbf{p}) + p\frac{\partial q_{-i}^j(\mathbf{p})}{\partial p_i^j} = 0. \tag{A.10}$$

In each case, the price vector $\mathbf{p}$ is evaluated at the same four prices: $\mathbf{p} = (p, p, p, p)$.

As in the text, let $p = p^{**}$ denote the solution to (A.9) and define $\mathbf{p}^{**} \equiv (p^{**}, p^{**}, p^{**}, p^{**})$ to be the vector of equilibrium prices. Then, by the definition of p^{**}, it follows that

$$p^{**}\frac{\partial q_i^j(\mathbf{p}^{**})}{\partial p_i^j} + q_i^j(\mathbf{p}^{**}) + p^{**}\frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j} = 0. \tag{A.11}$$

Evaluating the left-hand side of (A.10) at $p = p^{**}$ for all i, j, and using (A.11) yields

$$p^{**}\left(\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} - \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}\right), \tag{A.12}$$

which can be either positive, negative, or zero, depending on the sign of $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} - \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$.

The three bullet points in Proposition 1 follow immediately on noting that our assumptions imply that the left-hand side of (A.10) is decreasing in p when $\mathbf{p} = (p, p, p, p)$. Thus, for example, if the sign of (A.12) is positive, then the left-hand side of (A.10) is positive at $p = p^{**}$, implying that $p = p^{**}$ is less than the (symmetric) equilibrium RPM price, and if the sign of (A.12) is negative, then the left-hand side of (A.10) is negative at $p = p^{**}$, implying that $p = p^{**}$ is greater than the (symmetric) equilibrium RPM price. **Q.E.D.**

Comparative Statics for the Mixed Regime: In the mixed regime in which D_i adopts the agency model, the four first-order conditions that characterize the Bertrand equilibrium can be reduced to the following conditions, one to determine p_{-i}^j and one to determine p_i^j:

$$p_{-i}^j \frac{\partial q_{-i}^j(\mathbf{p})}{\partial p_{-i}^j} + q_{-i}^j(\mathbf{p}) + p_{-i}^j \frac{\partial q_{-i}^{-j}(\mathbf{p})}{\partial p_{-i}^j} \; = \; 0, \tag{A.13}$$

$$(1 - s_i)\left(p_i^j \frac{\partial q_i^j(\mathbf{p})}{\partial p_i^j} + q_i^j(\mathbf{p})\right) + (1 - s_{-i})\left(p_{-i}^j \frac{\partial q_{-i}^j(\mathbf{p})}{\partial p_i^j}\right) \; = \; 0. \tag{A.14}$$

Let $p_{-i}^j = BR_{-i}^*(p_i^j)$ be the solution to (A.13) and let $p_i^j = BR_i^a(p_{-i}^j, s_i, s_{-i})$ be the solution to (A.14). Then, it must be that in the equilibrium of the mixed regime in which D_i has RPM, retail prices satisfy $p_{-i}^j = BR_{-i}^*(BR_i^a(p_{-i}^j, s_i, s_{-i}))$ and $p_i^j = BR_i^a(BR_{-i}^*(p_i^j), s_i, s_{-i})$.

We now show that p_i^j, p_{-i}^j, and $p_i^j - p_{-i}^j$ will be increasing in s_i and decreasing in s_{-i}. Consider first the equilibrium p_i^j. Taking the derivative with respect to s_i yields

$$\frac{\partial p_i^j}{\partial s_i} \; = \; \frac{\partial BR_i^a}{\partial p_{-i}^j} \frac{\partial BR_{-i}^*}{\partial p_i^j} \frac{\partial p_i^j}{\partial s_i} + \frac{\partial BR_i^a}{\partial s_i}. \tag{A.15}$$

Rearranging this yields

$$\frac{\partial p_i^j}{\partial s_i} \; = \; \frac{\frac{\partial BR_i^a}{\partial s_i}}{\left(1 - \frac{\partial BR_i^a}{\partial p_{-i}^j} \frac{\partial BR_{-i}^*}{\partial p_i^j}\right)}. \tag{A.16}$$

Our assumptions on uniqueness imply that $\frac{\partial BR_i^a}{\partial p_{-i}^j}$ and $\frac{\partial BR_{-i}^*}{\partial p_i^j}$ are less than one in absolute value. It follows that the sign of $\frac{\partial p_i^j}{\partial s_i}$ will be the same as the sign of the numerator in (A.16), which is positive because the direct effect of an increase in s_i is to increase p_i^j.

Next, consider the equilibrium p_{-i}^j. Taking the derivative with respect to s_i yields

$$\frac{\partial p_{-i}^j}{\partial s_i} \; = \; \frac{\partial BR_{-i}^*}{\partial p_i^j}\left(\frac{\partial BR_i^a}{\partial p_{-i}^j} \frac{\partial p_{-i}^j}{\partial s_i} + \frac{\partial BR_i^a}{\partial s_i}\right). \tag{A.17}$$

Rearranging this yields

$$\frac{\partial p_{-i}^{j}}{\partial s_i} = \frac{\frac{\partial BR_{-i}^{*}}{\partial p_i^j}\frac{\partial BR_i^a}{\partial s_i}}{\left(1-\frac{\partial BR_{-i}^{*}}{\partial p_i^j}\frac{\partial BR_i^a}{\partial p_{-i}^j}\right)}. \tag{A.18}$$

Our assumptions on uniqueness imply that $\frac{\partial BR_{-i}^{*}}{\partial p_i^j}$ and $\frac{\partial BR_i^a}{\partial p_{-i}^j}$ are less than one in absolute value. It follows that the sign of $\frac{\partial p_{-i}^j}{\partial s_i}$ will be the same as the sign of the numerator in (A.18), which is positive because best-response curves are upward sloping and $\frac{\partial BR_i^a}{\partial s_i} > 0$.

It remains to establish that the difference $p_i^j - p_{-i}^j$ is increasing in s_i. Using (A.16) and (A.18), we note that the sign of $\frac{\partial p_i^j}{\partial s_i} - \frac{\partial p_{-i}^j}{\partial s_i}$ will be the same as the sign of $\left(1-\frac{\partial BR_{-i}^{*}}{\partial p_i^j}\right)\frac{\partial BR_i^a}{\partial s_i}$. Using the fact that $|\frac{\partial BR_{-i}^{*}}{\partial p_i^j}| < 1$ and $\frac{\partial BR_i^a}{\partial s_i} > 0$, it follows that this sign is indeed positive.

Proof of Lemma 3: We first establish the relationship between the equilibrium prices in any mixed regime. We then show that when $s_1 = s_2$, these prices are bounded by the equilibrium prices in the RPM and no RPM cases, respectively, as stated in Lemma 3.

When $s_1 = s_2$, the two conditions that characterize the Bertrand equilibrium in the mixed regime when only D_i adopts the agency model, (14) and (13), simplify to:

$$p_{-i}^j \frac{\partial q_{-i}^j(\mathbf{p})}{\partial p_{-i}^j} + q_{-i}^j(\mathbf{p}) + p_{-i}^j \frac{\partial q_{-i}^{-j}(\mathbf{p})}{\partial p_{-i}^j} = 0, \tag{A.19}$$

$$p_i^j \frac{\partial q_i^j(\mathbf{p})}{\partial p_i^j} + q_i^j(\mathbf{p}) + p_{-i}^j \frac{\partial q_{-i}^j(\mathbf{p})}{\partial p_i^j} = 0. \tag{A.20}$$

Let $p_{-i}^j = BR_{-i}^{*}(p_i^j)$ be the solution to (A.19). Then, using the definition of p^{**}, the fact that $BR_{-i}^{*}(p_i^j)$ is increasing in p_i^j, and $|\frac{\partial BR_{-i}^{*}}{\partial p_i^j}| < 1$, we have (i) for $p_i^j = p^{**}$, $p_i^j = BR_{-i}^{*}(p_i^j)$, (ii) for all $p_i^j < p^{**}$, $p_i^j < BR_{-i}^{*}(p_i^j) < p^{**}$, and (iii) for all $p_i^j > p^{**}$, $p_i^j > BR_{-i}^{*}(p_i^j) > p^{**}$.

Thus, to establish that $p_i^j = p_{-i}^j$, we need only establish that $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} = \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$ implies that in equilibrium $p_i^j = p^{**}$. To establish that $p_i^j < p_{-i}^j$, we need only establish that $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} < \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$ implies that in equilibrium $p_i^j < p^{**}$. And, to establish that $p_i^j > p_{-i}^j$, we need only establish that $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$ implies that in equilibrium $p_i^j > p^{**}$. But this is precisely what we found in the proof of Proposition 1 when we evaluated the left-hand side of (A.10) (which is same as (A.20) above) at $\mathbf{p} = (p^{**}, p^{**}, p^{**}, p^{**})$, and showed that it was either zero, negative, or positive depending on the sign of $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} - \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$.

In particular, we found that when $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} = \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$, the left-hand side of (A.20) is zero when evaluated at $\mathbf{p}^{**} = (p^{**}, p^{**}, p^{**}, p^{**})$. This means that the p_i^j that solves (A.20) given $p_{-i}^j = p^{**}$ is equal to p^{**}, and thus in equilibrium we know that $p_i^j = p^{**}$. When $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} < \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$, the left-hand side of (A.20) is negative at $\mathbf{p}^{**} = (p^{**}, p^{**}, p^{**}, p^{**})$. This means that the p_i^j that solves (A.20) given $p_{-i}^j = p^{**}$ is less than p^{**}, and thus in equilibrium we know that $p_i^j < p^{**}$ (since p_i^j will only further decrease when p_{-i}^j decreases). Lastly, when $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$, the left-hand side of (A.20) is positive at $\mathbf{p}^{**} = (p^{**}, p^{**}, p^{**}, p^{**})$. This means that the p_i^j that solves (A.20) given $p_{-i}^j = p^{**}$ is greater than p^{**}, and thus in equilibrium we know that $p_i^j > p^{**}$ (since p_i^j will only further increase when p_{-i}^j increases).

Having previously established the relationship between p^{aa} and p^{**}, and having just established the relationship between p_1^{a*} and p_2^{a*} (and also between p_1^{*a} and p_2^{*a}), it thus remains only to establish the relationship between p^{aa} and p_1^{a*} and between p_2^{a*} and p^{**}.

Consider first the relationship between p^{aa} and p_1^{a*}. When $s_1 = s_2$, the conditions that characterize the Bertrand equilibrium when only D_i adopts the agency model are given by (A.19) and (A.20). Evaluating them at $\mathbf{p} = (p^{aa}, p^{aa}, p^{aa}, p^{aa})$, we see that the left-hand side of (A.20) is zero (recall that $p = p^{aa}$ is the price that solves (10)), but the left-hand side of (A.19) may be zero, negative, or positive depending on the sign of $\frac{\partial q_{-i}^j(\mathbf{p^{aa}})}{\partial p_i^j} - \frac{\partial q_i^{-j}(\mathbf{p^{aa}})}{\partial p_i^j}$.

If $\frac{\partial q_{-i}^j(\mathbf{p^{aa}})}{\partial p_i^j} = \frac{\partial q_i^{-j}(\mathbf{p^{aa}})}{\partial p_i^j}$, then the left-hand side of (A.19) is zero when evaluated at $\mathbf{p} = (p^{aa}, p^{aa}, p^{aa}, p^{aa})$, which implies that $p^{aa} = p_1^{a*} = p_2^{a*}$ is the unique solution to (A.19) and (A.20). If $\frac{\partial q_{-i}^j(\mathbf{p^{aa}})}{\partial p_i^j} < \frac{\partial q_i^{-j}(\mathbf{p^{aa}})}{\partial p_i^j}$, then the left-hand side of (A.19) is positive when evaluated at $\mathbf{p} = (p^{aa}, p^{aa}, p^{aa}, p^{aa})$. This means that the p_{-i}^j that solves (A.19) given $p_i^j = p^a$ is greater than p^{aa}, and thus in equilibrium we know that $p_1^{a*} > p^{aa}$ (since the optimal p_i^j will then increase when p_{-i}^j increases). And, finally, if $\frac{\partial q_{-i}^j(\mathbf{p^{aa}})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p^{aa}})}{\partial p_i^j}$, then the left-hand side of (A.19) is negative when evaluated at $\mathbf{p} = (p^{aa}, p^{aa}, p^{aa}, p^{aa})$. This means that the p_{-i}^j that solves (A.19) given $p_i^j = p^{aa}$ is less than p^{aa}, and thus in equilibrium we know that $p_1^{a*} < p^{aa}$ (since the optimal p_i^j will then decrease when p_{-i}^j decreases).

Now consider the relationship between p_2^{a*} and p^{**}. Evaluating (A.19) and (A.20) at $\mathbf{p} = (p^{**}, p^{**}, p^{**}, p^{**})$, we see that the left-hand side of (A.19) is zero, but the left-hand side of (A.20) may be zero, negative, or positive depending on the sign of $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} - \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$.

If $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} = \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$, then the left-hand side of (A.20) is also zero when evaluated at $\mathbf{p} = (p^{**}, p^{**}, p^{**}, p^{**})$, which implies that $p^{**} = p_1^{a*} = p_2^{a*}$ is the unique solution to (A.19) and (A.20). If $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$, then the left-hand side of (A.20) is positive when evaluated at $\mathbf{p} = (p^{**}, p^{**}, p^{**}, p^{**})$. This means that the p_i^j that solves (A.20) given

$p^j_{-i} = p^{**}$ is greater than p^{**}, and thus in equilibrium we know that $p_2^{a*} > p^{**}$ (since the optimal p^j_{-i} will increase when p^j_i increases). And, finally, if $\frac{\partial q^j_{-i}(\mathbf{p}^{**})}{\partial p^j_i} < \frac{\partial q^{-j}_i(\mathbf{p}^{**})}{\partial p^j_i}$, then the left-hand side of (A.20) is negative when evaluated at $\mathbf{p} = (p^{**}, p^{**}, p^{**}, p^{**})$. This means that the p^j_i that solves (A.20) given $p^j_{-i} = p^{**}$ is less than p^{**}, and thus in equilibrium we know that $p_2^{a*} < p^{**}$ (since the optimal p^j_{-i} will decrease when p^j_i decreases).

Noting that the sign of $\frac{\partial q^j_{-i}(\mathbf{p^{aa}})}{\partial p^j_i} - \frac{\partial q^{-j}_i(\mathbf{p^{aa}})}{\partial p^j_i}$ is the same as the sign of $\frac{\partial q^j_{-i}(\mathbf{p}^{**})}{\partial p^j_i} - \frac{\partial q^{-j}_i(\mathbf{p}^{**})}{\partial p^j_i}$ (this is a consequence of the definition of p^{**} as the price p that solves (9) and of p^{aa} as the price p that solves (10), and our assumption that the left-hand sides of (9) and (10) are decreasing in p), and using the results from Proposition 1 and Lemma 3, we have thus shown that (i) if $\frac{\partial q^j_{-i}(\mathbf{p}^{**})}{\partial p^j_i} = \frac{\partial q^{-j}_i(\mathbf{p}^{**})}{\partial p^j_i}$, then $p^{aa} = p_1^{a*} = p_2^{a*} = p^{**}$, (ii) if $\frac{\partial q^j_{-i}(\mathbf{p}^{**})}{\partial p^j_i} < \frac{\partial q^{-j}_i(\mathbf{p}^{**})}{\partial p^j_i}$, then $p^{aa} < p_1^{a*} < p_2^{a*} < p^{**}$, and (iii) if $\frac{\partial q^j_{-i}(\mathbf{p}^{**})}{\partial p^j_i} > \frac{\partial q^{-j}_i(\mathbf{p}^{**})}{\partial p^j_i}$, then $p^{aa} > p_1^{a*} > p_2^{a*} > p^{**}$. **Q.E.D.**

Proof of Proposition 2: The proof of the first bullet point is in the text. To prove the second bullet point, we construct a linear-demand example that is similar to the one used by Rey and Verge (2010) to show that (i) there are settings in which each outcome can arise in equilibrium, (ii) the equilibrium outcome need not be unique, and (iii) for some of these settings, there is no equilibrium outcome in which the agency model is adopted.

Let the demand for good j at platform i be given by

$$q^j_i = 1 - \frac{\left(p^j_i - dp^j_{-i} - up^{-j}_i - dup^{-j}_{-i}\right)}{\kappa},$$

where

$$\kappa \equiv 1 - d - u - du > 0.$$

Then, in the no-delegation case (neither firm adopts the agency model), we have:

$$p^{**} = \frac{\kappa}{\kappa + (1-u)},$$

$$\pi^{**} = \frac{2s(1-u)\kappa}{[\kappa + (1-u)]^2}. \tag{A.21}$$

In the delegation case (both firms adopt the agency model), we have, for $s_1 = s_2 = s$:

$$p^{aa} = \frac{\kappa}{\kappa + (1-d)},$$

$$\pi^{aa} \;=\; \frac{2s(1-d)\kappa}{[\kappa+(1-d)]^2}. \tag{A.22}$$

And in the mixed regime in which only D_1 delegates, we have, for $s_1 = s_2 = s$:

$$p_1^{a*} \;=\; \Omega\,(d+3(1-u)-\kappa)\,\kappa \quad \text{and} \quad p_2^{a*} \;=\; \Omega\,(3-2u-\kappa)\,\kappa,$$

where $\Omega = \left[(2+u^2)\,(2-d^2) - 3u\,(2+d^2)\right]^{-1}$. Profits in this regime are

$$\pi_1^{a*} = 2s\Omega^2\left((2+d)\,\kappa + d\,(1+5u)\right)(d+3(1-u)-\kappa)\,\kappa, \tag{A.23}$$

$$\pi_2^{a*} \;=\; 2s\Omega^2\,(1-u)\left((3-2u)-\kappa\right)^2\kappa. \tag{A.24}$$

To support a Nash equilibrium in which neither firm adopts the agency model, it must be that $\pi^{**} - \pi_1^{a*} \geq 0$. Equations (A.21) and (A.23) imply that

$$\pi^{**} - \pi_1^{a*} = (d-u)\left((d-u) - \underbrace{\frac{d^2 p_1^{a*}\left((1-u)+\kappa\right)}{4\kappa\Omega\,(1+u)^{-2}\,(1-u)^3}}_{+}\right)\underbrace{\frac{2s\kappa 4\,(1-u)^3\,\Omega^2}{\left((1-u)+\kappa\right)^2}}_{+}. \tag{A.25}$$

From (A.25) we see that $(\pi^{**} - \pi_1^{a*}) > 0$ if $(d-u) < 0$. We thus have a Nash equilibrium in which no firm adopts the agency model if upstream substitution is greater than downstream substitution. If $(d-u) > 0$, then deviation may or may not be profitable depending on the sign of the term in brackets. Other things equal, it is more likely to be profitable if $(d-u)$ is relatively small. In particular, note that in the limit $u = 0$ we have

$$(\pi^{**} - \pi_1^{a*})|_{u=0} = \frac{d^2\,(1-d)^2}{(2-d^2)\,(2-d)^2}s > 0. \tag{A.26}$$

To support a Nash equilibrium in which both firms adopt the agency model, it must be that $\pi^{aa} - \pi_2^{a*} \geq 0$. Equations (A.22) and (A.24) imply that

$$\pi^{aa} - \pi_2^{a*} = (d-u)\left(\underbrace{\frac{d^2\,(2+u)\,(1+u)}{\Omega\,(1-u)\,(2-u)^2}}_{+} - (d-u)\right)\underbrace{\frac{2s\,(1-u)\,(2-u)^2\,\kappa\Omega^2}{\left((1-d)+\kappa\right)^2}}_{+}. \tag{A.27}$$

Equation (A.27) shows that deviation from the agency model is profitable if $(d-u) < 0$. In combination, equations (A.25) and (A.27) thus show that we have a unique equilibrium in which neither firm adopts the agency model. However, if $(d-u)>0$, then deviation may or may not be profitable depending on the sign of the term in brackets. If the sign of the bracketed term is positive, then deviation is unprofitable. Other things equal, the sign is more likely to be positive if $(d-u)$ is relatively small. For $u=0$ we have

$$\left(\pi^{aa} \;-\; \pi_2^{a*}\right)\big|_{u=0} = -d^2 \frac{1-d-d^2}{2\left(2-d^2\right)^2} s \;>\; 0, \tag{A.28}$$

Thus, deviation is unprofitable in this case if $d > d^{crit} = \frac{1}{2}\left(\sqrt{5}-1\right) \approx 0.62$.

Taken together, (A.26) and (A.28) thus imply that for $u=0$, we have a unique equilibrium in which neither firm adopts the agency model if $d < d^{crit}$, while for $d^{crit} < d < 1$ we have multiple equilibria; one where both adopt, and one where neither adopts.

Figure 4 illustrates the possible equilibria for all relevant parameter values. If $u > d$ we have a unique equilibrium in which neither firm adopts the agency model. The curve u^{aa} solves $(\pi^{aa} \;-\; \pi_2^{a*}) = 0$. Above this curve, no firm will unilaterally deviate from the agency model (given that $u < d$). In contrast, the curve u^{**} solves $(\pi^{**} \;-\; \pi_1^{a*}) = 0$. Below this curve no firm will unilaterally adopt the agency model. Between the curves u^{aa} and u^{**}, we thus have a region in which both or neither adopting the agency model can arise.

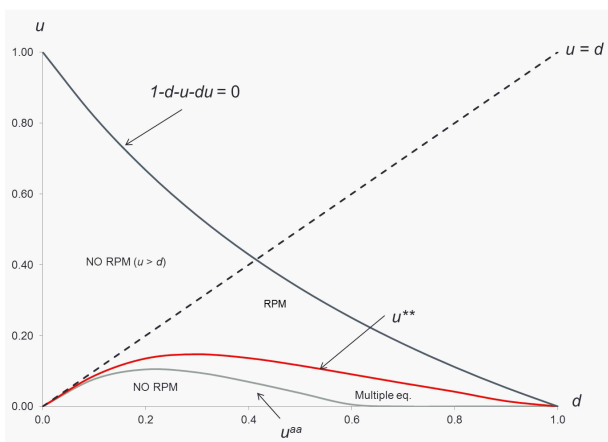

Figure 4

It follows that (i) if $u \geq d$ or $u < u^{aa}$, then the unique equilibrium is for neither firm to adopt the agency model; (ii) if $u \leq d$ and $u^{aa} \leq u \leq u^{**}$, then there are multiple equilibria (either both adopt the agency model, or neither adopts the agency model); and (iii) if $u \leq d$ and $u > u^{**}$, then the unique equilibrium is for both firms to adopt the agency model.

To support a mixed regime in which only D_1 adopts the agency model, it must be that $\pi_1^{a*} - \pi_1^{**} \geq 0$ and $\pi_2^{a*} - \pi_2^{aa} \geq 0$. We show that both relationships can occur if s_2 is sufficiently large relative to s_1. The proof of this last claim is available on request.**Q.E.D.**

Proof of Lemma 4: We have shown (see Lemma 3) that even in the absence of D_i's MFN clause, U^1 and U^2 would set $p_i^j < p_{-i}^j$ in equilibrium when the conditions in the first bullet point in Lemma 4 are satisfied. Hence, D_i's MFN clause would have no effect in equilibrium in this case. However, we also showed in Lemma 3 that when the conditions in the second bullet point in Lemma 4 are satisfied (i.e., $s_i \geq s_{-i}$ and $\frac{\partial q_{-i}^j(\mathbf{p}^{**})}{\partial p_i^j} > \frac{\partial q_i^{-j}(\mathbf{p}^{**})}{\partial p_i^j}$), D_i's MFN clause would be binding (because otherwise U^1 and U^2 would set $p_i^j > p_{-i}^j$ in equilibrium). Thus, in this case, it must be that all four prices are the same in any equilibrium.

We now show that no vector of prices $\tilde{\mathbf{p}} \equiv (\tilde{p}, \tilde{p}, \tilde{p}, \tilde{p})$ can be supported in equilibrium if $\tilde{p}$ is greater than $\min\{p^m, p^I\}$ or less than p^{**}. Consider first the case in which $\tilde{p} > \min\{p^m, p^I\}$. In this case, either D_{-i} would want to deviate by undercutting $\tilde{p}$, knowing that this would force U^1 and U^2 to match its price cuts, or U^j would want to deviate by undercutting $\tilde{p}$. In the first instance, this follows because if $\tilde{p} > \min\{p^m, p^I\} = p^I$, then by deviating to $p_{-i}^1 = p_{-i}^2 = p^I$ and having U^1 and U^2 match its prices, D_{-i} would earn $\Pi_{D-i}(\mathbf{p^I}) > \Pi_{D-i}(\tilde{\mathbf{p}})$). In the second instance, this follows because if $\tilde{p} > \min\{p^m, p^I\} = p^m$, then the left-hand side of (13) is negative when all prices are equal to $\tilde{p}$ (recall that (13) is satisfied with equality when all prices are equal to p^m)). Now consider the case in which $\tilde{p} < p^{**}$. In this case, D_{-i} would want to deviate by charging a higher price on its goods. This follows because the left-hand side of (14) is positive when all prices are equal and less than p^{**} (recall that (14) is satisfied with equality when all prices are equal to p^{**}).

Lastly, we show that the vector of prices $\tilde{\mathbf{p}} \equiv (\tilde{p}, \tilde{p}, \tilde{p}, \tilde{p})$ can be supported in equilibrium if $\tilde{p} \in [p^{**}, \min\{p^m, p^I\}]$. To see this, note that for all $\tilde{p}$ in this set, U^j would ideally want to increase its price above $\tilde{p}$ (this follows because for all $\tilde{p} \leq p^m$, the left-hand side of (13) is weakly positive when all prices are evaluated at $\tilde{p}$) but cannot do so because of the MFN clause, and D_{-i} would ideally want to charge a lower price on its two goods (this follows because for all $\tilde{p} \geq p^{**}$ the left-hand side of (14) is weakly negative when all prices are evaluated at $\tilde{p}$) but cannot do so without causing U^1 and U^2 to match its price cuts. **Q.E.D.**

Proof of Proposition 3: We have already seen that if the degree of substitution is relatively greater downstream, then retail prices will be the same on all products in any equilibrium with MFN clauses. We now establish the rest of the first two bullet points.

To prove that there exists an equilibrium in which at least one firm adopts the agency model and has an MFN clause, suppose without loss of generality that $s_i \geq s_{-i}$, and consider the candidate equilibrium in which D_i has an MFN clause and only D_i adopts the agency model. Suppose that in the equilibrium of the continuation game, $p = min\{p^m, p^I\}$. Then, it follows that if $s_i = s_{-i}$, $p = p^{aa}$, and if $s_i > s_{-i}$, $p > max\{p_i^{aa}, p^{aa}\}$. It also follows that D_i's profit is equal to $\Pi_{Di}(p^m, p^m, p^m, p^m)$ if $p^m \leq p^I$ and $\Pi_{Di}(p^I, p^I, p^I, p^I)$ if $p^m > p^I$.

To check for profitable deviations, note that if D_i does not adopt the agency model in this case, it will earn $\Pi_{Di}(p^{**}, p^{**}, p^{**}, p^{**})$, which is less than both $\Pi_{Di}(p^m, p^m, p^m, p^m)$ and $\Pi_{Di}(p^I, p^I, p^I, p^I)$. And, if it does adopt the agency model but does not have an MFN clause, it will earn $\Pi_{Di}(p_1^{a*}, p_1^{a*}, p_2^{a*}, p_2^{a*})$, which is also less than both $\Pi_{Di}(p^m, p^m, p^m, p^m)$ and $\Pi_{Di}(p^I, p^I, p^I, p^I)$. It follows that D_i does not have a profitable deviation. Now consider whether D_{-i} has a profitable deviation. If it adopts the agency model it will earn $\Pi_{Di}(p^{aa}, p^{aa}, p^{aa}, p^{aa})$ whether or not it also has an MFN clause. But this too is less than (or equal to) its profit in the candidate equilibrium. It follows that D_{-i}, like D_i, does not have a profitable deviation, and thus the candidate equilibrium is indeed an equilibrium.

By construction, this establishes the second bullet point. To prove the rest of the first bullet point, we still need to show that in *any* equilibrium in which at least one firm adopts the agency model and has an MFN clause, retail prices are the same and equal to p^{aa} when $s_i = s_{-i}$, and the same and greater than or equal to p^{aa} when $s_i > s_{-i}$. But this is so because we have already shown that retail prices cannot be the same and less than p^{aa} in any equilibrium involving MFN clauses, nor can they be the same and greater than p^{aa} in any equilibrium involving MFN clauses when $s_i = s_{-i}$ (because $p^m = p^{aa}$ when $s_i = s_{-i}$).

To establish the third bullet point, we suppose without loss of generality that $s_i \geq s_{-i}$ and note that Pareto optimality implies that in any equilibrium in which D_i has an MFN clause and only D_i adopts the agency model, retail prices will be the same on all products and equal to $p = min\{p^m, p^I\}$ in the continuation game. As in the discussion above, this leads to a profit for D_i of $\Pi_{Di}(p^m, p^m, p^m, p^m)$ if $p^m \leq p^I$ and $\Pi_{Di}(p^I, p^I, p^I, p^I)$ if $p^m > p^I$. In either case, D_i's profits are strictly greater than they would be if neither firm adopted the agency model, which implies that D_i would thus have a profitable deviation. **Q.E.D.**

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