THE AGENCY AND WHOLESALE MODELS IN ELECTRONIC CONTENT MARKETS

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ABSTRACT. I investigate strategic interactions and market outcomes in the "agency model" and "wholesale model" of sales. Adopting the agency model initially raises prices, and can (but need not) raise the profits of rival retailers. Nonetheless, consumers prefer the agency model. I relate my results to events in the market for electronic books.

I investigate the "agency model" and "wholesale model" of sales, which are two distinct ways of structuring relations between suppliers and retailers and of determining final retail prices. The wholesale model is very typical: suppliers set per-unit wholesale prices to retailers, who then set retail prices. The agency model is very different: suppliers set retail prices and then split revenue with retailers according to pre-determined shares.[1]

Adopting the agency model changes the operative strategic incentives in the market, leading to a different equilibrium market outcome. The agency model can raise retailer profits, which may encourage retail entry and benefit consumers. But even when entry and investment levels are fixed, consumers prefer the agency model—despite the fact that retail prices increase immediately following its adoption.

My analysis provides additional insight for regulators assessing markets that utilize the agency model. In particular, my results are relevant for the pending antitrust case in the US, in which Apple and some book publishers (who adopted the agency model) are accused of conspiring to raise prices for electronic books ("e-books"). The EC is also considering legal action.

In addition to being recently adopted by e-book retailers Amazon and Apple and publishers supplying them, the agency model is also commonly used by companies that support marketplaces for applications ("apps") usable on mobile devices such as smartphones and tablet computers, as well as the Amazon Marketplace (a channel for many retail goods). A variant of the agency model is also present whenever a salesperson vends goods of multiple producers who set the market price for their own goods and pay a commission for each sale.

Among my main results is that a simple condition determines retailers' preferences over the two pricing methods: whenever the differentiation between suppliers is sufficiently high

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[1]The terms "agency model" and "wholesale model" are not mine, but rather are used in practice.

compared to the differentiation of retailers, retailers prefer the agency model, but otherwise prefer the wholesale model. For example, everything else equal, if retailers are close substitutes for one another, then they prefer that suppliers set retail prices, whereas they prefer to set prices themselves when the suppliers' products are close substitutes.

This result also holds when consumers become locked into retailers. In the e-book market, consumer lock-in may exist because a consumer becomes accustomed to using, for example, Amazon's e-book store or e-book reading app. In some cases, lock-in exists because hardware either ties consumers to or guides them towards particular e-book reading apps.[2]

When there is lock-in, moving to the agency model has somewhat subtle retail price effects: initial prices increase but future prices decline, relative to the wholesale model. The reason that initial prices are lower under the wholesale model is that retailers compete intensely to lock in consumers, so that these consumers may be harvested in the future; suppliers do not share such incentives to subsidize early consumption, and so early prices are higher when suppliers set retail prices. The reason that future prices are lower under the agency model is that it ensures robust competition exists directly between suppliers, whereas the wholesale model allows the retailer to internalize competition between suppliers and more fully harvest locked-in consumers.

Thus, the observation of price increases following the adoption of the agency model is not sufficient to conclude that consumers have been injured. Rather, a complete assessment of consumer welfare must take a longer term perspective.

Indeed, another main result is that consumers typically prefer the agency model. This finding holds whether there is consumer lock-in or not—the same force that causes the agency model to produce lower future prices in the presence of lock-in actually leads to lower prices in all periods in the absence of lock-in.

Nonetheless, in some cases consumers can be harmed by the agency model; the agency model may align the incentives of retailers and suppliers so that retailers adjust their advertising and promotion decisions to reduce the choices available to consumers.

Suppliers may also benefit from the agency model. For example, the agency model may spur retail entry (because it raises retailer profits conditional on entry), allowing suppliers to avoid monopsony. In cases where retailers make choices that influence the competitiveness of the supplier market, as is the case when retailers can influence the set of products that consumers consider, the agency model also aligns the incentives of suppliers and retailers in a way that benefits suppliers.

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[2]The actual e-book market is rather complex in this regard. Some hardware devices offer multiple reading apps, but no device offers all apps. For example, on the iPad, consumers can use either Apple's app or Amazon's app. On most Android-based devices, consumers can use either Amazon's app or Google's app, but not Apple's. And on Amazon's Kindle device, consumers must buy their e-books from Amazon.

My work is related to the literature on strategic managerial delegation.[3] As first emphasized by Schelling (1956, 1960), it may be beneficial to delegate decisions to another agent when so doing provides commitment power. Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987) expand upon this point.

Gans (2012) also investigates pricing under the agency model, similarly motivated by markets such as those for e-books and apps. However, he does not focus on how the agency model differs from the wholesale model, but instead identifies a hold-up problem when app providers set prices after consumers invest in joining a new and more efficient platform. This problem may be so significant that consumers do not adopt the new platform in equilibrium. Most-favored-nation clauses can solve this problem by imposing a price cap on the app.

Although the goal of my analysis is not to provide a complete description of each event and fact surrounding any particular market, my results are consistent with several key facts surrounding the e-book market, and generate additional insight into that market.

In 2010, Apple entered the e-book market as it introduced its tablet computer, the iPad. Prior to Apple's entry, Amazon was the the only significant player in the market, selling e-books for its dedicated e-book reader, the Kindle.

Publishers had been unhappy dealing exclusively with Amazon. One reason is that Amazon had been selling many e-books, most notably best sellers and new releases, at substantial discounts to the prices of physical copies of such books. Indeed, Amazon priced many e-books beneath its wholesale cost. One argument of publishers was that this practice would erode the long-term value of the book market by reducing the willingness to pay of consumers.

Apple convinced publishers to adopt the agency model as a condition of its entry into e-book retailing, and publishers then pressured Amazon to do so as well. Following this, the price of many e-books significantly increased, in particular for those books that previously had been highly discounted.

In April, 2012, the US Department of Justice accused Apple and five major publishers of conspiring to increase the price of e-books. The Justice Department did not claim that the agency model itself was anticompetitive, instead pointing to meetings between publishers, and of course the increase in e-book prices, as evidence of a conspiracy. Nonetheless, the Justice Department is advocating for abandoning the agency model.

My analysis suggests caution in assessing the competitive impact of the agency model. For example, although my analysis acknowledges that prices should go up following the adoption

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[3]My work is connected to that on incentives in principal-agent relationships. As explained by Sappington (1991), revenue- or profit-sharing contracts have been examined in many contexts, and can provide incentives while also balancing risk. There are many important applications, including to cropsharing (Allen and Lueck (1992)) and movies (Chisholm (1997)). Much of this literature assumes there is a single agent on one or both sides of the market, and focuses on optimal incentive schemes. In contrast, my main question is how the identity of the firms chosen to make the key strategic decisions matters, when there is competition both upstream and downstream.

of the agency model, it also suggests that prices should go down in the long run, benefiting consumers. Additionally, the higher retailer profits under the agency model may further benefit consumers by encouraging entry of retailers, who must make investments in online storefronts, apps for reading e-books, and even physical devices such as the iPad, the Kindle, and the Nook (produced by Barnes & Noble), or, in the case of Google, the Android operating system for tablets and smartphones.

1. The Model and Preliminary Results

I begin with a broad description of the model before separately considering the demand and supply sides in more detail.

There are two symmetric retailers, labeled A and B, and N symmetric suppliers indexed by n. Each supplier sells its product through both retailers (or "multihomes"). The products of the N suppliers are arrayed uniformly on a standard "circular city", and the retailers are situated at the ends of a unit-length Hotelling line. Costs are set to zero.

There are two periods. In the first period, consumers choose a retailer and then select a particular product. Consumers become locked into whichever retailer they purchase from in period one.

Consumer lock-in provides a convenient way to generate predictions that match events in the e-book market, but as I will argue later this assumption is not crucial for many of my results. As noted earlier, the actual e-book market is somewhat complex, and lock-in may flow from a combination of factors including costs of becoming familiar with new online stores, apps, or even hardware.

Figure 1 provides a conceptual overview of the market in graphical form, for the case in which there are eight suppliers.

1.1. **The demand side.** A consumer first selects a retailer. Upon so doing, he observes a random variable $x \in [0, 1]$ that gives his location on a circle of circumference one, where x is uniformly distributed. He next chooses from among N products, where product n sold by retailer i has price p_{in}^1—the superscript 1 indicates these are first-period prices.

A consumer x who has chosen retailer i and product n receives utility

$$v - t_u d(x, n) - p_{in}^1,$$

where $d(x, n) \geq 0$ gives the distance between x and product n and $t_u > 0$ is a parameter measuring upstream differentiation. He purchases one product, unless doing so would yield negative utility, in which case he purchases no product this period. Thus, it is as if this
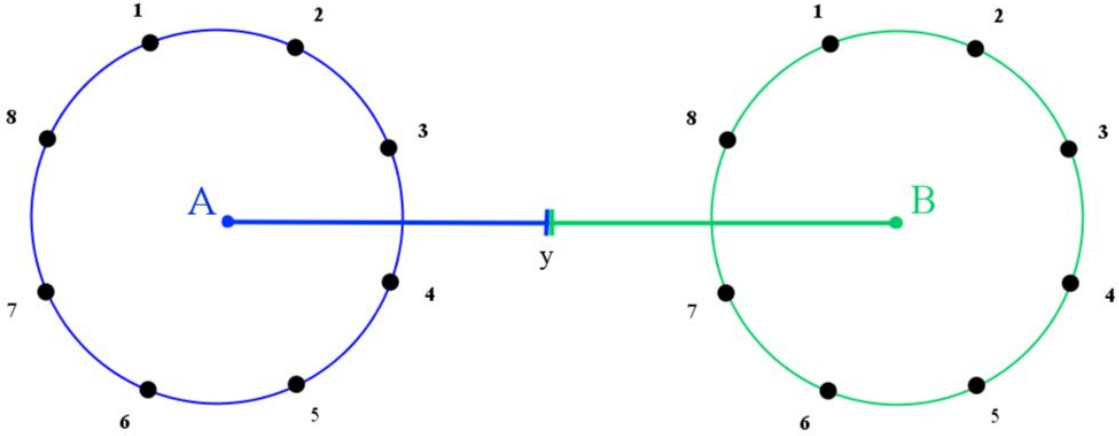
FIGURE 1. Blue colors indicate retailer A and also the mass of consumers y who are buying from retailer A, whereas green colors correspond to retailer B and the consumers who purchase from it. Each of the eight suppliers sells its product through both retailers.

consumer lives in a standard "circular city" as in Salop (1979), although his exact location in the city is not determined until after his choice of A or B.[4]

In the second period, this consumer again buys a product, subject to his outside option of zero, given prices p_{in}^2. He is locked into whichever retailer he chose in period one.

Consider the initial choice of retailer. Define

$$U(p) = E_x[\max_n (v - t_u d(x, n) - p) \, |x].$$

$U(p)$ gives the expected within-period utility (as x varies) of a consumer, given that all products are priced at p.[5]

Let $\bar{p}_i^1$ and $\bar{p}_i^2$ denote the average price of the products sold by retailer i in periods one and two, respectively. I assume that the mass of consumers who purchase from A, denoted by y, is defined implicitly by

$$U(\bar{p}_A^1) + U(\bar{p}_A^2) - t_d y = U(\bar{p}_B^1) + U(\bar{p}_B^2) - t_d(1 - y).$$

If $\bar{p}_A^2 = \bar{p}_B^2$, as will be the case in equilibrium, then

$$y = \frac{\bar{p}_B^1 - \bar{p}_A^1 + t_d}{2t_d}, \tag{1}$$

corresponding to a static Hotelling demand system with prices $\bar{p}_i^1$.[6]

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[4]Such an assumption is required to generate tractable analysis, given that I allow for differentiation both between retailers and suppliers, and that I allow for consumers to have preferences over both suppliers and retailers.

[5]Throughout, I look for equilibria that are symmetric, wherever possible, both within and across retailers, and in retail prices and (under the wholesale model) wholesale prices.

[6]This interpretation also requires that consumers believe each retailer is charging the same price for each product, given $\bar{p}_i$.

1.2. **The supply side and equilibrium in the agency model.** In the agency model, each supplier simultaneously sets retailer-specific retail prices in each period. The revenue generated by sales of product n through retailer i is split between n and i, with r_i denoting the share taken by the supplier. These shares are fixed and taken as given.

Consider a representative supplier, say firm 1, choosing its second-period price for, say, retailer A, p_{A1}^2, given that other suppliers are charging p_A^2 through A. Letting $x_1(p_{A1}^2, p_A^2)$ denote the proportion of consumers selecting this product amongst all consumers who buy from A, supplier 1 chooses its price to maximize

$$y r_A p_{A1}^2 x_1(p_{A1}^2, p_A^2) = y r_A p_{A1}^2 \left(\frac{p_A^2 - p_{A1}^2 + \frac{t_u}{N}}{t_u} \right).$$

This is proportional to a firm's profits in a standard circular city model, and hence leads to the same equilibrium prices. These prices are identical across suppliers and retailers, independent of the revenue shares r_i, and given by

$$p_{An}^2 = p_{Bn}^2 = \frac{t_u}{N}, \text{ for each } n.$$

Now consider the first period. Firm 1's profit function is

$$r_A y \left[p_{A1}^1 x_{A1}^1 + p_{A1}^2 x_{A1}^2 \right] + r_B (1-y) \left[p_{B1}^1 x_{B1}^1 + p_{B1}^2 x_{B1}^2 \right],$$

where the mass of consumers y purchasing from A is a function of the average price levels $\bar{p}_A^1$ and $\bar{p}_B^1$, and given by Equation (1). x_{A1}^τ and x_{B1}^τ give the proportion of consumers who demand this firm's product contingent on selecting either retailer A or B, $\tau \in \{1, 2\}$.

Incorporating what is known about second-period pricing, this reduces to

$$r_A y \left[p_{A1}^1 x_{A1}^1 + \frac{t_u}{N^2} \right] + r_B (1-y) \left[p_{B1}^1 x_{B1}^1 + \frac{t_u}{N^2} \right].$$

In this period, each supplier's prices influence which retailer consumers purchase from. Intuitively, each supplier has an incentive to bias prices to drive demand to whichever retailer is offering it a greater revenue share.

Proposition 1. *In the agency model, second-period retail prices are given by $p_A^2 = p_B^2 = \frac{t_u}{N}$. If $r_i > r_j$, then first-period retail prices satisfy $p_i^1 < \frac{t_u}{N} < p_j^1$. Hence, $r_A = r_B$ implies that $p_A^1 = p_B^1 = \frac{t_u}{N}$ in period one.*

1.3. **The supply side and equilibrium in the wholesale model.** Under the wholesale model, in each period τ suppliers simultaneously set retailer-specific wholesale prices w_{in}^τ, and then retailers set retail prices. To ensure that the analysis is tractable, I assume that retailers have a limited ability to price discriminate: retailers can set prices for product n to consumer x that depend on whether x is "to the left" or instead "to the right" of product n.

More precisely, prices can depend on whether x lies between products $n-1$ and n or instead between n and $n+1$.[7]

In defense of this assumption, note the following. First, in equilibrium all consumers are charged the same prices for each good. Second, allowing suppliers to similarly price discriminate in the agency model has no effect on the equilibrium. Third, and most importantly, the basic results of this article are driven by economic forces that seem unlikely to hinge crucially on this particular assumption.

Suppose it is the second period, and consider a representative interval of length $1/N$ between, say, products 1 and 2. Suppressing time and retailer-specific notation, the indifferent consumer x_1 satisfies

$$p_1 + t_u x_1 = p_2 + t_u \left(\frac{1}{N} - x_1 \right) \iff x_1 = \frac{p_2 - p_1 + \frac{t_u}{N}}{2t_u},$$

which is the demand from a Hotelling interval of length $1/N$.[8]

Unlike in a standard Hotelling model, the retailer sets both prices and hence internalizes any pricing externalities; p_1 and p_2 are chosen to maximize the profits of the representative per-interval profit function of a retailer, given by

$$(p_1 - w_1)x_1 + (p_2 - w_2) \left(\frac{1}{N} - x_1 \right),$$

subject to the constraint that the marginal consumer receives non-negative utility.

As verified in the appendix, the optimal selection of prices leads to a value of x_1 given by

$$x_1 = \frac{w_2 - w_1 + \frac{2t_u}{N}}{4t_u}. \tag{2}$$

To derive the equilibrium wholesale prices, suppose that all suppliers other than 1 are charging w. Because 1 is selling to consumers located on either side of it, it wishes to maximize

$$2w_1 x_1 = w_1 \left(\frac{w - w_1 + \frac{2t_u}{N}}{2t_u} \right).$$

Differentiating to obtain the first-order condition and imposing $w_1 = w$ yields equilibrium second-period wholesale prices (including full time and retailer-specific notation) of

$$w_{An}^2 = w_{Bn}^2 = \frac{2t_u}{N}.$$

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[7]Without this assumption, the presence of both upstream and downstream differentiation causes the demand curve and overall objective function faced by any given supplier to be very complex. Generally a retailer would wish to adjust all N retail prices by different amounts in response to the change in a single supplier's wholesale price, and moreover this is so even fixing the retailer's overall market share.

[8]In the analysis of the wholesale model, x_1 refers to the demand from "one side" of a product, whereas in an abuse of notation, in the analysis of the agency model x_1 to refer to the demand from both sides of a product.

Because each retailer will set the same second-period prices in equilibrium, in period one consumers choose between A and B based solely on average first-period prices $\bar{p}_A^1$ and $\bar{p}_B^1$. Suppliers recognize that they can influence these retail price levels, and hence y, through their own choice of wholesale prices. Because supplier's second-period profits do not depend on the outcome of the first period, in period one a supplier n maximizes first-period profits:

$$w_{An} x_{An} y + w_{Bn} x_{Bn} (1 - y).$$

As verified in the appendix, equilibrium wholesale prices are the same as in period 2.

Given symmetric wholesale prices, and suppressing retailer and time notation, retailer A chooses $\bar{p}_A^1$ to maximize

$$\left[\left(\bar{p}_A^1 - w_A^1 \right) + \left(p_A^2 - w_A^2 \right) \right] y = \left[\bar{p}_A^1 - \left(w_A^1 + w_A^2 - p_A^2 \right) \right] \left(\frac{\bar{p}_B^1 - \bar{p}_A^1 + t_d}{2 t_d} \right).$$

This is the same profit function faced by a standard static Hotelling competitor with marginal costs $w_A^1 + w_A^2 - p_A^2$, given that consumers have transportation costs t_d. The same is true for B. Hence, in equilibrium

$$\bar{p}_i^{\,1} = t_d + w_i^1 - (p_i^2 - w_i^2).$$

The first-period price equals the retailer differentiation parameter plus the first-period wholesale price plus less the retailer's second-period margin—retailers subsidize prices because they value locking consumers in.

Summarizing and extending the work above yields the following result. Additional details are in the appendix.

Proposition 2. *There exists a unique symmetric equilibrium under the wholesale model of sales. In it, first- and second-period wholesale prices are equal and given by*

$$w_{in}^\tau = \frac{2 t_u}{N}.$$

Retail prices are given by

$$p_{in}^2 = v - \frac{t_u}{2N}, \quad \text{and} \quad p_{in}^1 = t_d + \frac{2 t_u}{N} - (p_{in}^2 - w_{in}^2).$$

2. ANALYSIS

Here I examine how moving from the wholesale model to the agency model influences the market equilibrium, including the payoffs of consumers, retailers, and suppliers. I take the revenue shares as given and equal under the agency model, so that $r_A = r_B = r \in (0, 1)$.

One might wonder whether fixing the revenue shares in this manner invalidates later results. However, most of my results do not require particular assumptions about the exact configuration of parameters. In other words, most of my results are valid no matter what underlying

(potentially endogenous) process yields the revenue shares. One exception is that for some results (namely, Corollary 1 and Proposition 5) I assume that v is large. However, as inspection of the proofs of these propositions reveals, allowing r to depend on v does not overturn these results. Regardless, it seems likely that v would not influence r. Another exception involves my analysis of retailer preferences, in particular Propositions 3 and 4. I return to the question of endogenous r after presenting those results, where I argue that allowing r to change with other parameters introduces an additional force, but need not negate the force behind the propositions as stated.

An earlier version of this paper incorporated an initial stage in which retailers made r_i offers to suppliers. I showed that retailers had incentives to impose most-favored-nation clauses. Intuitively, the presence of most-favored-nation clauses such as those observed in the e-book market can influence the determination of revenue shares. Such clauses limit the ability of publishers to reward retailers who offer them higher revenue shares (or punish those who offer lower shares), and have the net effect of softening competition between retailers in these shares, thereby reducing the equilibrium revenue shares that publishers receive.

2.1. **Price Trajectory.** My first result deals with market prices.

Corollary 1. *For v sufficiently large, moving from the wholesale model to the agency model raises first-period retail prices but lowers second-period retail prices.*

Many e-book prices rose following the move to the agency model, so that the prediction about first-period prices is consistent with the facts. The prediction that future prices should be lower under the agency model is novel and suggests that the overall effect of moving to that sales model is somewhat subtle.

The reason that first-period prices rise under the agency model is that suppliers and retailers value consumer lock-in very differently. More specifically, locking in a consumer is valuable to a retailer, because so doing allows it to monopolize that consumer in the future. Retailers therefore have incentives to compete fiercely in the first-period, and indeed they charge less than the wholesale price in that period so long as the second-period market is sufficiently valuable (as measured by v).

In contrast, a supplier has no incentive to subsidize first-period consumption, because it sells through both retailers in both periods. This unwillingness to subsidize implies that first-period prices are higher under the agency model.

The reason that second-period prices are lower under the agency model is that the agency model ensures that retail competition is left in the hands of all N suppliers as opposed to monopoly retailers. That is, because of consumer lock-in, when retailers set prices they act as monopolists in the second period, internalizing the competition between rival suppliers

that would otherwise prevail, and charging high retail prices. In contrast, the agency model maintains direct retail price competition between suppliers, causing lower retail prices.

Consumer lock-in is not crucial for the agency model to lead to lower prices, where the absence of such lock-in is defined to be the model in which the second period is a replication of the first.

Corollary 2. *Suppose that there is no consumer lock-in. Then moving from the wholesale model to the agency model lowers retail prices in both periods.*

The intuition for Corollary 2 is very simple. Under the agency model, suppliers compete directly with one another, just as if the retail market were perfectly competitive. In contrast, there is double marginalization under the wholesale model, so that prices are higher.[9]

Corollary 2 emphasizes that lock-in, or some other strategic link between periods, is required for prices to increase in the first period following a move to the agency model. Thus, to explain the increase in e-book prices following the move to the agency model requires a dynamic motive.

There are several strategic incentives other than lock-in that that might provide such a motive, giving retailers incentives to charge low prices in early periods. In the e-book market in particular, there are two leading possibilities.

First, there might be predatory intent, with Amazon in particular hoping to weaken or eliminate "brick and mortar" rivals. Second, there might be network effects; if it is costly to support multiple versions of e-books that work with different retailers' e-book apps, then retailers may desire to build initial market share to secure a future competitive advantage.

If either predatory intent or network effects are present, then retailers who set their own prices have incentives to charge low prices early on, with the expectation of having greater market power in the future. Because suppliers do not share these pricing incentives, moving to the agency model has the same price effects as identified in Corollary 1: higher first-period prices and lower second-period prices.

2.2. **Retailer profits.** Recall that t_d measures retailer differentiation and t_u measures supplier differentiation.

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[9]Although the prediction that second-period prices should be lower when suppliers set retail does not depend on lock-in, such lock-in certainly influences the second-period price reduction that occurs when the market moves to the agency model. In particular, the size of this second-period retail price reduction is larger when there is consumer lock-in. The reason is that, when retailers set prices, lock-in ensures that retailers are unconstrained in their second-period pricing; there is more room for prices to fall when there is lock-in.

Proposition 3. *There exists a value ρ^* such that the profits of retailers are higher under the agency model than under the wholesale model if and only if*

$$\frac{t_u}{t_d} > \rho^*.$$

Proposition 3 indicates that retailers prefer the agency model whenever upstream differentiation is strong relative to downstream differentiation. To understand this result, first note that, under the wholesale model, the profits that retailers capture are determined by t_d.[10] Second, the absence of a retailer markup under the agency model means that retail prices are the outcome of direct competition between suppliers and hence not influenced by t_d but instead determined solely by t_u. That is, because suppliers sell through both channels, the equilibrium outcome of their pricing conflict ignores retailer differentiation.

In other words, the level of retailer profits is determined by the level of differentiation in the stage of the supply chain where retail prices are set. When retailers set these prices, downstream differentiation is the main determinant of their profits, whereas when suppliers set them it is the differentiation between suppliers that is crucial.

The tradeoff that retailers face can also be explained in terms of lock-in. By placing pricing power in the hands of suppliers, retailers avoid the intense upfront competition to lock in consumers that leads to the dissipation of second-period profits, which are increasing in t_u.

On the other hand, first-period prices under the agency model effectively throw away the differentiation that exists between retailers, measured by t_d. Thus, moving to the agency model carries a benefit that is increasing in t_u, but also a cost that is increasing in t_d.

The first intuition does not involve consumer lock-in, suggesting that similar forces are at work in its absence.

Proposition 4. *Suppose that there is no consumer lock-in. Then there exists a value ρ^{**} such that the profits of retailers are higher under the agency model than under the wholesale model if and only if*

$$\frac{t_u}{t_d} > \rho^{**}.$$

Also, lock-in increases the attractiveness of the agency model for retailers: $\rho^{**} > \rho^*$.

An interesting implication of Proposition 4 is that retailers may prefer the agency model despite the fact that it leads to lower retail prices in both periods (as shown in Corollary 2). The reason this happens, of course, is that retailers care about their per-unit profits and not simply the retail prices, and these profits depend on who is setting prices.

With or without lock-in, retailers gain when they delegate retail pricing decisions to the segment of the supply chain that has the greatest differentiation.

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[10]Although the retail price is influenced by t_u, that portion of it is captured by suppliers through wholesale prices.

Nonetheless, the relative attractiveness of the agency model is higher when there is consumer lock-in: $\rho^{**} > \rho^*$. The reason is that second-period profits are fully dissipated in the whole-sale model when there is lock-in, because of intense first-period price competition, whereas such is not the case without lock-in. Because second-period profits are never dissipated under the agency model, the presence of lock-in provides an additional boost to retailer profits when moving away from the wholesale model.

Propositions 3 and 4 are related to the literature on strategic managerial delegation. As first emphasized by Schelling (1956, 1960), it may be beneficial to delegate decisions to another agent when so doing provides commitment power. Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987) expand upon this point. They argue that firms may benefit by implementing incentive schemes that reward managers for outcomes such as revenue or output, rather than profits. By credibly changing the incentives of managers, a firm's reaction function shifts, potentially altering the market equilibrium in a way that benefits the firm.[11]

Here, moving to the agency model changes the equilibrium outcome in the market because suppliers have different profit functions than retailers. Indeed, moving to the agency model shifts the retail competition in the market from being inter-retailer to inter-supplier. While intuitively similar, there are two key differences compared to the existing literature on managerial delegation. First, suppliers are not merely employees but instead are firms that just happen to reside in another part of the supply chain. Second, under the agency model each supplier makes pricing decisions for all retailers, not just one. That is, suppliers do not represent any given retailer in the way that managers represent given firms in the delegation literature.

Katz (1991) argues that, when each principal signs an unobserved contract with a single agent, the strategic effects identified by the delegation literature disappear, and it is as if each principal made decisions directly. In the present context, there is common agency, with each supplier making decisions on behalf of both retailers, and so that result is not directly applicable. Moreover, Katz's arguments suggest that there would be no difference between the wholesale model equilibrium and the agency model equilibrium. However, the evidence is strong that, in the e-book market at least, moving to the agency model did in fact change the industry equilibrium. So, it may be that contracts are reasonably taken as observable in the e-book market. Finally, in the e-book market, there are typically most-favored-nation clauses. Such clauses would limit the ability of a retailer to profitably and secretly renegotiate with a single supplier (using more complex contracts than currently considered). The reason is that so renegotiating could only be profitable if it ended up

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[11]Schelling's insight has also been applied more generally, for example to questions of firm financial structure (Brander and Lewis (1986)) and bargaining (Jones (1989)).

conferring a retail price advantage to a particular retailer, that is, if it caused a supplier to bias its retail prices in favor of the renegotiating retailer. However, if the other retailer has a most-favored-nation clause, that will not be possible. Indeed, under the agency model, prices are observable and so such clauses are readily enforced.

Propositions 3 and 4 are statements about what happens in different regions of parameter space, but fix r. Unlike previous results, which were claims that held regardless of what parameters were, these claims are sensitive to the critique that r might differ across regions.

To investigate, suppose that r is an increasing function of t_u/t_d. As shown in the proof of Proposition 3, in the case of lock-in retailers prefer the agency model if and only if

$$\frac{t_u}{t_d}\left(1 - r\left(\frac{t_u}{t_d}\right)\right) > \frac{N}{2}.$$

Differentiating the left-hand side with respect to t_u/t_d gives

$$\left(1 - r\left(\frac{t_u}{t_d}\right)\right) - \frac{t_u}{t_d}r'\left(\frac{t_u}{t_d}\right).$$

Clearly, a tension is now introduced, and if r' is sufficiently large in some regions, for example, this expression need not be positive, so that there need not be a threshold result. Indeed, for very extreme values, the tension is quite acute. For example, if $t_d \approx 0$, it may be expected that $r_i \approx 0$, whereas r_1 might be much larger if $t_u \approx 0$.

Nonetheless, the basic force identified in the propositions above still exists—having suppliers set prices means that there are no incentives to strategically slash prices in early periods, but limits the ability to internalize price competition in later periods.

Retail competition is a crucial driver of Propositions 3 and 4. For example, a monopolist retailer faces no competitive threat and so does not subsidize consumer purchases in the first period. Because the agency model leads to lower second-period prices, the agency model is unattractive to a monopoly retailer, so long as the value of monopolizing the second period (measured by v) is sufficiently large.

Proposition 5. *If there is a single retailer, then its profits are higher under the wholesale model, for v sufficiently large.*

Proposition 5 is consistent with the facts of the e-book market. The incumbent player, Amazon, did not push for the agency model. Rather, it was the entrant, Apple, who convinced key publishers to adopt it. These publishers then forced Amazon to adopt the agency model, using the entry of Apple as leverage.

2.3. **Consumer welfare.** Corollary 1 indicates that consumers face higher initial prices under the agency model, but lower future prices. Nonetheless, consumers have clear preferences over the two sales models.

Proposition 6. *Consumer welfare is higher under the agency model.*

Consumers are unambiguously worse off under the wholesale model, even though the intense first-period retail price competition that accompanies it causes retailers to dissipate—indeed, transfer to consumers—the entirety of their second-period monopoly profits.

Proposition 6 follows from three observations. First, under the agency model, there is no retailer markup and so conceptually it is as if suppliers compete through a perfectly competitive retail segment in which wholesale prices are passed directly to consumers. Second, under the wholesale model, supplier competition is softened because retailers do not fully pass through wholesale price cuts; this leads to higher wholesale prices. These two observations imply that the sum of wholesale prices across the two periods is higher under the wholesale model.

The final observation is that the total retail prices that consumers pay over time must at least weakly exceed the total wholesale prices. In other words, although retailers may be willing to subsidize initial purchases, they will not choose negative profits across the two periods combined. It follows that consumers prefer the agency model.

Note that Proposition 6 does not merely follow from the familiar idea of double marginalization under bilateral monopoly (although this is indeed the basis for why consumers prefer the agency model in the absence of lock-in).[12] After all, when retailers set final prices, there is a negative retailer markup in the first period.

Instead of double marginalization, a key here is that under the wholesale model competition between suppliers is softened and this works to raise the total price that consumers pay over both periods. This result is somewhat related to the observation of Bonanno and Vickers (1988) that suppliers using two-part tariffs and operating through exclusive retailers may gain by remaining "vertically separated" as opposed to being integrated. Very loosely speaking, in the present environment the agency model is similar to vertical integration, whereas the wholesale model is similar to vertical separation, although there are neither two-part tariffs nor exclusive deals in either case of my model.

Another reason that consumers may be better off under the agency model is that retailers may have stronger incentives to invest or enter under that model. That is, as demonstrated in Propositions 3 and 4, the agency model can raise retailer profits, which may therefore encourage investments.

This prospect is consistent with the facts surrounding the e-book market. For example, Apple agreed to enter that market only after suppliers accepted the agency model—prior to Apple's entry, the wholesale model was in place. William Lynch, the CEO of Barnes & Noble

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[12]If there is no lock-in, then consumers must prefer the agency model because, as shown in Corollary 2, retail prices are lower in both periods.

(the maker of the Nook e-reader), argues that the agency model was crucial for the success of the Nook, and to justify Barnes & Noble's $200 million investment in the market.[13]

Amazon, Apple, and Barnes & Noble certainly needed to make many investments to become significant players in the e-book market. In addition to developing online stores, retailers must reach agreements with many supplies and convince them to publish e-books that are compatible with their reading devices or apps, and advertise and promote their store. Each of these three players has also invested in creating their own hardware devices.

Indeed, retailers are seemingly the main drivers of the adoption of e-books. It is therefore plausible that the agency model may ensure investment incentives for such players, and ultimately benefit consumers.

This is related to the idea that vertical restraints may influence profitability and investment incentives in the supply chain. For example, Telser (1960) argues that resale price maintenance (RPM) serves such a role.[14]

2.4. **Supplier profits.** As mentioned above, one feature of the wholesale model is that it softens wholesale price competition. Hence the following result is intuitive.

Proposition 7. *The profits of suppliers are higher under the wholesale model.*

This result might seem to be at odds with the facts surrounding the e-book market. After all, suppliers agreed to move to the agency model, following Apple's lead.

However, this fact does not actually contradict Proposition 7 (indeed, publishers were well aware that their per-unit profits would be higher under the wholesale model). The reason is that Apple demanded the agency model as a condition of its entry into the e-book market, suggesting that the appropriate question is whether suppliers prefer a monopoly retailer under the wholesale model or multiple retailers under the agency model.[15]

Because a monopoly retailer might be able to dictate prices or other terms of trade to suppliers, it is plausible that publishers would be willing to accept the agency model if so doing would encourage entry by additional retailers. In addition to entry allowing publishers to secure better wholesale prices, it is possible that such entry would more generally allow publishers to maintain control of the market.[16]

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[13]See "Paper Trail," by Ken Auletta, *The New Yorker*, June 25, 2012.

[14]More recently, Asker and Bar-Isaac (2011) argue a contrasting perspective, which is that RPM (and similar tools) can discourage entry. In their work, RPM is a way for an upstream firm to bribe downstream firms to discourage them from working with an entrant. Similar ideas exist in the exclusive dealing literature when retailers compete, as in Johnson (2012).

[15]Recall that Proposition 5 indicates that a monopolist retailer prefers the wholesale model.

[16]A second reason, put forth by publishers, is that low retail prices would undermine the long-run willingness to pay of consumers, which would ultimately harm publishers.

A closely related reason that suppliers might prefer the agency model is that it may induce favorable marketing and promotional activities in existing retailers. For instance, such marketing activities may be able to affect the outcome of competitive rivalry between publishers by influencing the set of products that consumers consider.

In the case of e-books, retailers can readily make suggestions to consumers or otherwise guide them to consider options that they otherwise would not. One reason is that it is easy to "personalize" the experience that a repeat consumer has when visiting an online store. For example, an online retailer may know a repeat consumer's purchase or search history, and be able to guide him to additional purchasing options of relevance.

To explore this most easily within the context of the existing model, suppose that there are two potential levels of competition, measured by N, among suppliers, N_L and $N_H > N_L$. In period one, $N = N_L$, but in period two each retailer separately chooses $N \in \{N_L, N_H\}$ as a proxy for being able to influence the competitiveness of the supplier market.

For uninteresting reasons, it is also necessary to suppose that all players put a weight of $\beta > 1$ on period two payoffs. Equivalently, the model could be extended to allow for more than one period of lock-in.

Proposition 8. *Suppose that in period 2 each retailer chooses $N \in \{N_L, N_H\}$, where $N_L < N_H$, and that second-period payoffs are weighted by $\beta > 1$. Then:*

(1) *Each retailer chooses N_H under the wholesale model, but chooses N_L under the agency model. Total supplier profit is always higher with $N = N_L$.*
(2) *Everything else fixed, and for N_H and β sufficiently large, (total) supplier profit is higher under the agency model than the wholesale model.*

An increase in N intensifies wholesale price competition and thereby raises second-period retailer profits at the expense of supplier profits—assuming that the wholesale model is in effect. In contrast, under the agency model, this increase in competition between suppliers is bad for retailers because the profits of a retailer are a share of (gross) supplier profits.

In other words, the agency model aligns the preferences of suppliers and retailers, whereas in the wholesale model they are at odds. Although such alignment may be good for suppliers, it is bad for consumers because it leads them to face a more limited selection of products.

Proposition 8 therefore identifies a potential welfare cost of the agency model, in addition to providing an explanation for why suppliers may prefer that model.

The basic concept underlying Proposition 8 is broadly consistent with evidence from the book market. Major publishers are concerned that the move to e-books, especially with a dominant retailer, will reduce their ability to influence which books consumers purchase, possibly leading to lower profits. Indeed, brick and mortar stores are sometimes seen as

vassals of dominant publishers in that these publishers have sway over what products are marketed to consumers. If true, this is a privileged position that these publishers may not wish to lose.

3. Conclusion

A market's decision to structure itself according to the agency model or instead the wholesale model amounts to a strategic delegation decision—will retail price competition occur between suppliers or instead between retailers? Because retailers and suppliers have different objectives, this delegation influences equilibrium market outcomes.

Broadly speaking, the agency model eliminates strategic incentives of retailers to slash prices in early periods, and hence raises early prices. However, the agency also model ensures robust competition directly between suppliers in later periods, thereby lowering future prices.

Although I have focused on consumer lock-in as the operative mechanism behind retailers' desire to charge low initial prices, there are other mechanisms that may generate the same predictions. For example, retailers may wish to cut early prices so as to build market share in order to take advantage of network effects and disadvantage rivals in future periods. Or, retailers may wish to encourage consumer experimentation with a new distribution channel.

Inasmuch as such incentives are weaker for suppliers, moving to the agency model will initially lead to higher prices. However, future prices will be lower because of the elimination of future double markups.

Thus, under a variety of strategic environments, the proper assessment of consumer welfare must carefully consider not just the initial effect on prices, but also long-run effects on prices and investments. Although a simple point, ignoring it readily leads to incorrect conclusions.

For example, under consumer lock-in and when the available products are fixed, consumers unambiguously prefer the agency model despite the initial price increases. This conclusion is strengthened when retailer investment and entry are important considerations, because the agency model may encourage these by raising retailer profits.

Even in the absence of intertemporal strategic considerations such as lock-in, my main conclusions continue to hold. In fact, the results are more direct: the agency model leads to lower prices in all periods, thereby benefiting consumers. Despite these lower prices, retailers prefer the agency model in qualitatively the same circumstances as when there is lock-in—whenever upstream differentiation is sufficiently stronger than downstream differentiation.

There are at least two limitations of my analysis, and so it serves only as an initial foray. One limitation that is relevant for the e-book market, and also may matter in other applications, is that I do not explicitly model the existence of an alternative channel for suppliers, namely

higher cost brick and mortar stores selling physical copies of books. Accommodating this possibility might be a very interesting direction for future analysis, especially given the role that retailers play in marketing competing books to consumers.

A second limitation is that I do not consider platforms as such, but in the real world most of the main e-book retailers also sell physical devices that host the applications that are used to read e-books. That said, in the e-book market, the situation is somewhat complex. For example, on some but not all platforms there are competing e-book applications.[17] Furthermore, platform pricing is complicated by the fact that most modern hardware devices provide book-reading capabilities as only one of many features. Thus, hardware pricing is influenced by a host of considerations beyond details of the e-book market. Despite these complications, investigating the role of platforms may be interesting.

<div align="center">PROOFS</div>

Proof of Proposition 1: I suppress time notation in this proof. Define $h(p_1, p) = p_1 x_1(p_1, p) + t_u/N^2$, and let $h_1(p_1, p)$ denote the partial derivative with respect to the first argument. Then, the profit of, say, supplier 1, is

$$\pi_1 = r_A y h(p_{A1}, p_A) + r_B(1-y)h(p_{B1}, p_B),$$

given that all other suppliers are charging p_A through retailer A and p_B through retailer B (and keeping in mind that this supplier's second-period profits through retailer i are $r_i t_u/N^2$.

In an abuse of notation, I will write $h(p) = h(p, p)$ and $h_1(p) = h_1(p, p)$. At an equilibrium (p_A^*, p_B^*), the following two conditions are satisfied:

$$\frac{\partial \pi_1}{\partial p_{A1}} = r_A y h_1(p_A^*) + \frac{dy}{dp_{A1}}[r_A h(p_A^*) - r_B h(p_B^*)] = 0, \text{ and} \tag{3}$$

$$\frac{\partial \pi_1}{\partial p_{B1}} = r_B(1-y)h_1(p_B^*) + \frac{dy}{dp_{B1}}[r_A h(p_A^*) - r_B h(p_B^*)] = 0. \tag{4}$$

Observe that

$$\frac{dy}{dp_{A1}} = \frac{1}{N}\frac{\partial y}{\partial \bar{p}_A} = -\frac{1}{N}\frac{\partial y}{\partial \bar{p}_B} = -\frac{dy}{dp_{B1}}.$$

Hence Equations (3) and (4) jointly imply that

$$r_A y h_1(p_A^*) = -r_B(1-y)h_1(p_B^*). \tag{5}$$

Because $h_1(p) = x_1(p, p) - p/t_u = 1/N - p/t_u$, it is positive for $p < t_u/N$ and negative for $p > t_u/N$. Thus, Equation (5) implies that p_A^* and p_B^* are (weakly) on opposite sides of t_u/N, so that, for example, if $p_A^* \geq t_u/N$ then $p_B^* \leq t_u/N$.

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[17]For example, on the Apple iOS platform, consumers have access to an Amazon app and also an Apple app, and on most Android devices, consumers have access to an Amazon app and a Google app (and in principle Apple could provide an app on that platform as well). In contrast, Amazon's Kindle does not support rival e-reading apps.

Let $r_A > r_B$, and suppose for the sake of contradiction that

$$p_B^* \leq \frac{t_u}{N} \leq p_A^*.$$

$h(p)$ is increasing, giving $h(p_A^*) \geq h(p_B^*)$, so that $r_A h(p_A^*) > r_B h(p_B^*)$. Using Equation (3), $h_1(p_A^*) > 0$. But as described above, this requires that $p_A^* < t_u/N$, a contradiction. ∎

Proof of Proposition 2: Consider, say, retailer A in the second period. Given whatever wholesale prices it faces, it wishes to maximize the profits from a representative interval

$$\pi(p_1, p_2) = (p_1 - w_1)x_1 + (p_2 - w_2)\left(\frac{1}{N} - x_1\right). \tag{6}$$

subject to the participation constraint of the marginal consumer

$$v - p_1 - t_u x_1 \geq 0.$$

The Lagrangean for this problem is

$$L = \pi(p_1, p_2) - \lambda(v - p_1 - t_u x_1),$$

with first-order conditions

$$\frac{\partial L}{\partial p_1} = x_1 - \frac{(p_1 - w_1)}{2t_u} + \frac{(p_2 - w_2)}{2t_u} + \frac{\lambda}{2} = 2x_1 - \frac{1}{2N} + \frac{(w_1 - w_2)}{2t_u} + \frac{\lambda}{2} = 0, \text{ and}$$

$$\frac{\partial L}{\partial p_2} = \frac{(p_1 - w_1)}{2t_u} + \left(\frac{1}{N} - x_1\right) - \frac{(p_2 - w_2)}{2t_u} + \frac{\lambda}{2} = -2x_1 + \frac{3}{2N} - \frac{(w_1 - w_2)}{2t_u} + \frac{\lambda}{2} = 0.$$

Hence the optimal x_1 can be determined as follows:

$$\frac{\partial L}{\partial p_2} - \frac{\partial L}{\partial p_1} = 4x_1 - \frac{2}{N} + \frac{(w_1 - w_2)}{t_u} = 0 \Longleftrightarrow x_1 = \frac{w_2 - w_1 + \frac{2t_u}{N}}{4t_u}.$$

This confirms Equation (2).

Now consider period 1. Given the wholesale prices, A wishes to maximize the representative interval's profit as before, but now subject to the constraint that average prices equal whichever $\bar{p}_A$ it wishes to offer consumers. Equivalently, it wishes to maximize

$$\pi(p_1, p_2) = (p_1 - w_1)x_1 + (p_2 - w_2)\left(\frac{1}{N} - x_1\right),$$

subject to the constraint that

$$\frac{p_1 + p_2}{2} \leq \bar{p},$$

where $\bar{p}$ is the optimal price level in this interval.

The Lagrangean is

$$\pi(p_1, p_2) - \lambda\left(\bar{p} - \frac{p_1 + p_2}{2}\right).$$

But this generates the same first-order conditions from the analysis of period two, and hence generates the same wholesale-demand function, namely that in Equation (2).

The next step is to determine the equilibrium wholesale prices. The period two prices are derived in the text, so consider the first period. Suppose all other suppliers are charging w through both retailers, and consider supplier 1. Because this supplier's second-period profits do not depend on y, its optimal wholesale prices, w_{A1} and w_{B1}, maximize

$$w_{A1}x_{A1}(w_{A1}, w)y + w_{B1}x_{B1}(w_{B1}, w)(1 - y) = w_{A1}x_1(w_{A1}, w)y + w_{B1}x_1(w_{B1}, w)(1 - y),$$

where x_1 in either case is given by Equation (2), setting $w_2 = w$. Although w_{A1} and w_{B1} may influence y through the effect on $\bar{p}_A$ and $\bar{p}_B$, supplier 1 can do no better than to maximize the two terms in this expression independently. In other words,

$$w_{A1} = w_{B1} = \arg\max_{w_1} w_1 x_1(w_1, w).$$

Thus, equilibrium wholesale prices in period 1 are $2t_u/N$, the same as in period 2. ∎

Proof of Corollary 1: Using Propositions 1 and 2, and letting p_{AG}^τ and p_{WS}^τ denote the prices in period τ of the agency and wholesale models, gives

$$p_{WS}^1 = t_d + \frac{9t_u}{N} - v, \ p_{WS}^2 = v - \frac{t_u}{2N}, \ \text{and} \ p_{AG}^\tau = \frac{t_u}{N}.$$

Hence, it follows that

$$p_{WS}^1 - p_{AG}^1 = t_d + \frac{7t_u}{2N} - v, \ \text{and} \ p_{WS}^2 - p_{AG}^2 = v - \frac{3t_u}{N}.$$

The result follows. ∎

Proof of Corollary 2: Consider the second period of the agency model for supplier 1, and suppress time notation. Define $\tilde{h}(p_1, p) = p_1 x_1(p_1, p)$, so that second-period profits are $ry\tilde{h}(p_{A1}, p_A) + r(1 - y)\tilde{h}(p_{B1}, p_B)$. Replicating the analysis in the proof of Proposition 1, but with $\tilde{h}$ instead of h, and leaning on the assumption maintained in Section 2 that $r_A = r_B$, it follows that second-period prices are given by t_u/N. But this means that, from the perspective of period one, this supplier's profit function is

$$\pi_1 = r_A y h(p_{A1}, p_A) + r_B(1 - y)h(p_{B1}, p_B).$$

The existing proof of Proposition 1 can be applied, so that first-period prices are t_u/N.

Now consider the wholesale model. In both the first and the second period, as in the proof of Proposition 2 that deals with the first period, conditional on some target price level $\bar{p}$ (which may depend on wholesale prices), each retailer sets retail prices to maximize the profits of a representative interval. Ergo, the wholesale-demand functions are the same as

derived earlier. Following further the steps in that proof, retail prices are simply a mark-up of t_d over wholesale prices of $2t_u/N$, and hence given by $2t_u/N + t_d$ in each period.

The result follows from the fact that

$$\frac{2t_u}{N} + t_d > \frac{t_u}{N}.$$

■

Proof of Proposition 3: Proposition 2 implies that the total retailer profits (that is, of both retailers and across both periods) in the wholesale model are (suppressing supplier and retailer-specific subscripts)

$$(p^1 - w^1) + (p^2 - w^2) = [t_d - (p^2 - w^2)] + (p^2 - w^2) = t_d.$$

In the agency model, Proposition 1 implies that the total retailer profits are

$$2(1-r)\frac{t_u}{N}.$$

The agency profits are higher if and only if

$$2(1-r)\frac{t_u}{N} > t_d \iff \frac{t_u}{t_d} > \frac{N}{2(1-r)}.$$

■

Proof of Proposition 4: Using the work in the proof of Corollary 2, the total retailer profits (that is, of both retailers and across both periods) in the wholesale model are $2t_d$, whereas in the agency model the total retailer profits are $2(1-r)\frac{t_u}{N}$. Profits are higher under the agency model if and only if

$$2(1-r)\frac{t_u}{N} > 2t_d \iff \frac{t_u}{t_d} > \frac{N}{(1-r)}.$$

Comparing this to the critical value of t_u/t_d in the case of no lock-in, given in the proof of Proposition 3, the result follows. ■

Proof of Proposition 5: Consider, say, supplier 1, supposing that other suppliers are charging w. The work in the proof of Proposition 2 implies that second-period equilibrium wholesale prices are equal to $2t_u/N$. This implies that a supplier's second-period profits are $2yt_u/N^2$, where y is the mass of consumers who purchase from A given a zero outside option in period one.

From the standpoint of period 1, this supplier maximizes

$$2y\left(w_1 x_1(w_1, w) + \frac{t_u}{N^2}\right).$$

At the first-period equilibrium wholesale price w^*, the following first-order condition holds

$$y\left(x_1(w^*, w^*) + w^* \frac{\partial x_1}{\partial w_1}\right) + \frac{dy}{dw_1}\left(w_1 x_1(w_1, w) + \frac{t_u}{N^2}\right)$$
$$= y\left(\frac{1}{2N} - \frac{w^*}{4t_u}\right) + \frac{dy}{dw_1}\left(\frac{w^*}{2N} + \frac{t_u}{N^2}\right) = 0.$$

Because $dy/dw_1 < 0$, it must be that

$$\frac{1}{2N} - \frac{w^*}{4t_u} > 0 \iff w^* < \frac{2t_u}{N}.$$

This shows that first-period wholesale prices are lower when there is a monopoly retailer. Hence, in either period, A faces wholesale costs no larger than $2t_u/N$.

It can similarly be shown that retail prices under agency are lower than when there are duopoly retailers, that is, lower than t_u/N. Hence, even if A received the entirety of agency profits, an upper bound for its profits would be $2t_u/N$. In contrast, under the wholesale model, second-period prices are $v - t_u/2N$, so as to extract maximum consumer surplus. Because these profits are not dissipated in period one (as they are in the presence of competition), it follows that the profits of a monopolist are increasing in v without bound under the wholesale model, thus proving the result. ∎

Proof of Proposition 6: Because there is no consumption distortion, the result follows if the sum (across periods) of retail prices is lower under the agency model. From Proposition 1, retail prices under the agency model are identical across periods and given by t_u/N, for a total of $2t_u/N$. Using Proposition 2, the total of prices under the wholesale model are $t_d + 4t_u/N$, which is higher. ∎

Proof of Proposition 7: Suppressing retailer and product specific subscripts, Proposition 1 implies that the total profits of all suppliers (and across both periods) is $2r(p^1 + p^2) = 2rt_u/N$. From Proposition 2, the corresponding total under the wholesale model is $w^1 + w^2 = 4t_u/N$, which is higher. ∎

Proof of Proposition 8: A retailer's per-customer profit in period two is given by $\beta(v - t_u/2N - 2t_u/N)$, and so in period two retailers will choose $N = N_H$. Under the agency model, this profit is $\beta(1-r)t_u/N$, and so in period two retailers choose N_L under the agency

model. Total supplier profits in period one are rt_u/N, and $\beta rt_u/N$ in period two, which are decreasing in N. This proves part (1) of the proposition.

To prove part (2), and using the work in the proof of Proposition 7, total supplier profits under the wholesale model are

$$w^1 + \beta w^2 = \frac{2t_u}{N_L} + \beta \frac{2t_u}{N_H},$$

whereas under the agency model these profits are

$$r(p^1 + \beta p^2) = r\left(\frac{t_u}{N_L} + \beta \frac{t_u}{N_L}\right) = \frac{rt_u}{N_L}(1 + \beta).$$

Hence, supplier profits are higher under the agency model if and only if

$$\frac{r}{N_L}(1 + \beta) > \frac{2}{N_L} + \beta \frac{2}{N_H} \iff \beta\left(\frac{r}{N_L} - \frac{2}{N_H}\right) > \frac{2 - r}{N_L}.$$

For N_H sufficiently large, the term in parentheses on the left-hand side is positive, and hence increasing in β. Hence, this condition holds for β and N_H large. ■

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