Refusal to Deal, Intellectual Property Rights, and Antitrust

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Abstract. A vertically integrated firm, having acquired the intellectual property (IP) through innovation to become an input monopolist, can extract surplus by supplying efficient downstream competitors. That the monopolist would refuse to do so is puzzling and has led to numerous debates in antitrust. In this paper, I clarify the economic logic of refusal to deal, and identify conditions under which prohibiting such conduct would raise or lower consumer and social welfare. I further show how IP protection (as determined by IP laws) and restrictions on IP holders' conduct (as determined by antitrust laws) may interact to affect innovation incentive and post-innovation market performance.

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1. INTRODUCTION

Should a monopolist have an antitrust duty to supply an intermediate good to competitors? The monopoly position for the intermediate good may have been acquired through the ownership of certain intellectual property (IP) and/or of some unique physical assets. In the U.S., courts have taken the view that IP owners have a presumptive right to refuse to sell or license products incorporating the IP to competitors. In a case involving Xerox's refusal to sell patented replacement parts and copyrighted service manuals to competing service providers in the copier repair market, the Federal Circuit ruled, upholding a lower court's decision, that such refusal to deal by the IP holder does not violate antitrust laws. Affirming a more general principle, the U.S. Supreme Court ruled in *Trinko* (2004) that firms have no antitrust duty to share their property (or source of advantage), in this case telecommunications network, with competitors.[1] In Europe, however, competition authorities and courts have in several influential cases found that it is a violation of competition law for a dominant firm to refuse to supply certain information, a special type of intermediate good under IP protection, to downstream rivals, as in *Magill* (1995), *IMS* (2004) and, more recently, the much publicized EC *microsoft* case.[2]

The wide divergence of court opinions across the Atlantic poses important challenges to economists.[3] In a thought-provoking recent article, Vickers (2010) states: "(the case examples illustrate that) tension between competition principles and property right principles, as well as their intrinsic interest, are economic policy questions of the first order of impor-

[1] For these two cases, see respectively: *CSU L.L.C., et al. v. Xerox Corp., Fed. Cir., No. 99-1323*, decided February 17, 2000; and *Verizon Communications Inc v Law Offices of Curtis V. Trinko LLP*, 540 US 398 (2004).

[2] RTE, ITP & BBC v. Commission, 1995 E.C.R. II-485; Case C-418/01, IMS Health v. NDC Health, 2004 E.C.R. I-5039; and Microsoft v Commission, T-201/04, 2007. See Vickers (2010) for more discussions.

[3] Even in the U.S., the issue remains controversial. Earlier court cases have imposed antitrust liability for unilateral refusal to deal, as, for example, in *Aspen Skiing v. Aspen Highlands Skiing, 472 U.S. 585 (1985),* and *Eastman Kodak v. Image Technical Servs, 504 U.S. 451 (1992).* In fact, according to the U.S. Federal Trade Commission, "One of the most unsettled areas of antitrust law has to do with the duty of a monopolist to deal with its competitors." (*FTC Guide to the Antitrust Laws*, http://www.ftc.gov/bc/antitrust/refusal_to_deal.shtm, accessed on February 23, 2011.)

tance." The purpose of this paper, inspired by Vickers, is to clarify the economic logic of refusal to deal and to evaluate the economic merits of alternative policies concerning such conduct, focusing on the especially controversial case where the monopolist's intermediate good is produced with IP created through innovation.

The first step in my analysis, rather than inquiring whether antitrust law should compel a monopolist to supply a rival, addresses a more basic question that has not been well understood in the economics literature and policy discussions: why would a monopolist refuse to supply a rival? One answer, implicit in arguments advocating an antitrust liability, is that the monopolist seeks to extend its monopoly power from the upstream to the downstream market. The "Chicago School", however, would dispute the plausibility of such anticompetitive vertical foreclosure, based on the logic of there being only one monopoly profit (which implicitly assumes a perfectly competitive downstream market). When the downstream market is not perfectly competitive, the one-monopoly logic is generally not correct: by charging its monopoly price for the input, the upstream monopolist could extract surplus from efficient downstream competitors, which provides a second source of profit to the monopolist but can sometimes also lead to inefficient foreclosures.[4] But this only adds to the puzzle: if a monopolist can potentially extract surplus from supplying a downstream rival, why would it refuse to deal?[5]

The solution to this puzzle, as I shall argue, is to consider dynamic incentives in the vertical industry structure. Although the upstream monopolist has the monopoly power for the input now, there might be a future follow-on innovation by another firm that creates a "better" input. By not supplying the downstream rival now, the monopolist may either reduce this possibility or maintain monopoly profit through downstream dominance even when the upstream market becomes competitive. This strategic, or "anticompetitive" motive, may outweigh the short-term benefits of surplus extraction from supplying the downstream competitors. Thus, anticompetitive refusal to supply a downstream rival may indeed occur, but

[4] See, for example, Vickers (2010), who also points out that this is related to Aghion and Bolton (1987)'s classic analysis on how exclusive contracts can be profitably used to extract surplus from potential entrants.

[5] One could, of course, resort to explanations based on transaction costs or contracting failures, which we should discuss shortly, but the puzzle for the argument favouring an antitrust liability still is: where is the anticompetitive motive for refusal to deal?

only when future *upstream* competition from follow-on innovation is (sufficiently) likely.

This potential anticompetitive motive, however, should be considered in the context of other potential motives when evaluating an antitrust liability for refusal to deal. There might be additional fixed (setup or transaction) cost to supply the downstream rival, relative to supplying one's own downstream producer. When the variable profits under monopoly pricing is not high enough to cover such costs, the monopolist will find it optimal to refrain from supplying the rival. I shall call this the cost motive,[6] which may include related reasons such as bargaining or contracting failures.[7] I develop an analytical framework in which the strategic and cost motives can be disentangled and assessed. I further demonstrate how these motives are affected by the prevailing IP protection and how they in turn affect the equilibrium market structure.

After clarifying the economic logic of refusal to deal, I next study the consumer and social welfare effects of three antitrust policies: prohibiting a monopolist's refusal to deal, restricting the monopolist's input price but without prohibiting refusal to deal, or both prohibiting refusal to deal and restricting the input price. The initial upstream innovation incentive is taken into account, in addition to the subsequent strategic interactions in the industry. I find that prohibiting refusal to deal leads to (weakly) lower consumer and social welfare when future follow-on innovation is sufficiently unlikely, but to (weakly) higher consumer and social welfare when both transaction and innovation costs are small enough. On the other hand, restricting input price alone, in the form of imposing the efficient component pricing rule (ECPR), always leads to (weakly) lower consumer welfare, whereas prohibiting refusal to deal together with ECPR can either increase or reduce consumer and social welfare.

I further consider how the two different aspects of intellectual property rights (IPRs), the strength of IP protection (as determined by IP laws) and possible restrictions on IP holders' conduct (as determined by antitrust laws), may interact to affect innovation incentives and

[6] It is well known that market transactions can involve additional transaction costs (e.g., Williamson, 1980).

[7] Contracting failure might occur when the monopolist is unable to charge its profit-maximizing price. In the absence of strategic considerations, the monopolist generally could do better by charging this price than refusal to deal, since the latter is equivalent to a sufficiently (infinitely) high price.

post-innovation market performance. In particular, I show that IP protection and antitrust are partial substitutes as policy instruments in promoting consumer welfare: the desirability for restrictive antitrust policies (i.e., prohibiting refusal to deal) is reduced under strong IP protection (for the initial innovation); and, conversely, strong IP protection becomes less desirable under restrictive antitrust policies.

This research is related to the economics literature on tying and foreclosure. In his seminal contribution, Whinston (1990) demonstrates that a monopolist in one market can use tied sales to foreclose competition in another market. Whinston's analysis focuses on the monopolist's ability to use tying to induce exit of a rival in the tied market so as to increase current profitability there. Carlton and Waldman (2001) introduce important dynamic considerations and show that a monopolist in its primary market can use tying of a complementary product to maintain its monopoly position by deterring future entry into the primary market. In their two-period model, this occurs because tying can eliminate the competitor's profit and thus deter it from producing the complementary product in period 1, and entry to the primary market in period 2 then becomes unprofitable to the competitor.[8] My analysis is closely related to these studies, since refusal to deal also excludes competition. However, in addition to refusal to deal being a different business practice that is still much debated and less understood, both the model and the potential anticompetitive mechanism uncovered here have important differences from those in the tying literature. In particular, unlike under tying where goods from both markets are sold directly to final consumers, in my model of vertical markets the input is sold to (and used by) downstream producer(s) who then supply final consumers. As such, vertical control is a key element of the potential anticompetitive mechanism under refusal to deal, which enables the input monopolist to earn monopoly industry profit even when the upstream market becomes competitive in the future.[9]

This paper is also related to other studies on antitrust in innovative industries, particularly Segal and Whinston (2007), who in a setting of continual innovation analyze how

[8] See also Choi and Stefanadis (2001) for another important model of dynamic foreclosure through tying.

[9] Another major difference is that my explicit consideration of innovation incentives and of coordinating IP and antitrust policies.

antitrust policies restricting incumbent behavior towards *horizontally competing* entrants affect innovation incentives. By considering a model of vertical industry competition and the interactions between IPRs and antitrust, this study introduces new considerations and complements their analysis.[10] The research is further related to the literature on vertical foreclosure (e.g., Ordover, Saloner, and Salop, 1990; Choi and Yi, 2000; and Chen, 2001). My finding, that a vertically integrated firm may refuse to supply a downstream rival in order to maintain vertical control in the presence of potential upstream competition, adds a new insight to the literature.

The rest of the paper is organized as follows. Section 2 formulates a stylized continuous-time model where initially a firm can invent a new intermediate good (input) through investment. Section 3 analyzes the market equilibrium, considering both the innovation decision and post-innovation strategic interactions. Section 4 studies the consumer and social welfare effects of antitrust policies that prohibit refusal to deal and/or restrict the monopolist's pricing for the input. Section 5 analyzes possible optimal coordination of IP protection and antitrust. Section 6 discusses several modeling issues, possible extensions, and case examples. Section 7 concludes. Proofs that do not appear in the text are gathered in an appendix.

2. THE MODEL

There are two vertically related industries, U and D. A vertically integrated firm, M, has an upstream division denoted as U1 and a downstream division denoted as D1. Time is continuous. At $t = 0$, U1 has an opportunity to invent a new intermediate good by investing $k > 0$.[11] The strength of intellectual property protection for the innovation, possibly through a patent or copyright, is denoted by $\alpha \in [0, 1]$, where a higher α indicates stronger protection, with 0 and 1 corresponding respectively to no protection and perfect protection.

[10] See also Scotchmer (2004) for important discussions about IPRs and competition policy, and Chen and Sappington (2011) on how exclusive contracts affect innovation and welfare.

[11] We may think the innovation opportunity as the arrival of an innovation idea, which needs the investment cost k to implement, as in Green and Scotchmer (1995). The investment cost can be the realization of some random variable; for our purpose we shall treat it as a parameter of the model.

The intermediate good, whose marginal cost of production is normalized to zero, can be used to produce a homogeneous retail (final) product in D by D1 or/and by a separate firm, D2. The production of the final product uses the input through a one-to-one fixed proportion technology. The downstream production by D1 has instantaneous constant marginal cost c, whereas production by D2 has uncertain instantaneous constant marginal cost c_2, which for any $t \geq 0$ is an independent draw of a random variable distributed with c.d.f. $F(c_2)$ and p.d.f. $f(c_2) > 0$ on $[\underline{c}, \bar{c}]$, where $0 \leq \underline{c} \leq c < \bar{c}$.[12] At $t = 0$, U1 chooses whether to offer the intermediate good for sale to D2. If it does, U1 incurs a one-time setup cost $\tau \geq 0$ in order to transact with D2, and then posts wholesale price w to D2, which can be adjusted instantaneously at any $t > 0$.[13] To provide a meaningful and convenient analysis of antitrust restrictions on U1's actions, we assume that D2 can enter the market only if U1 chooses to supply D2 at $t = 0$.[14] The discount rate for all parties is r. All firms aim to maximize expected profits.

An independent firm in U, U2, may arrive after $t = 0$ with a follow-on innovation to produce a higher-quality input at a marginal cost also normalized to zero. U2's innovation is possible only if U1 innovates at $t = 0$. The arrival time of U2 follows a Poisson distribution with arrival rate $\lambda(\alpha) > 0$, where $\lambda'(\alpha) \leq 0$ to capture the idea that a follow-on innovation is more likely when there is less IP protection for the initial innovation. For given α, we simply denote this arrival rate by λ.[15] By using U2's input, active downstream producers, which include D1 and possibly D2 if D2 has also been an active producer, will have a lower marginal cost of downstream production, c_L, with $c_L \leq \underline{c}$. When both U1 and U2 are present

[12] Thus D1 and D2 each may have a cost advantage at different points of time. This is a convenient way to introduce a potentially efficient reason to have both firms in the market, even though they produce a homogeneous product. We could allow D1 and D2 to produce differentiated products or to both have uncertain costs, but these alternative settings would be less tractable than the formulation we adopt here.

[13] The setup cost may be due to technical specifications or adjustments that need to be made to the input for use by D2. For the main model, we only consider linear input prices, same as for the final good. We later discuss how to extend the analysis to situations where general vertical contracts are feasible.

[14] Thus U1 can exclude D2 by not supplying it at $t = 0$. This could be the case, for example, if U1 can commit to its decision through some irreversible technical choice in its product design at $t = 0$ (as in Choi and Yi, 2000). Then, it could be optimal for D2 not to enter even in a more general model where the entry decision is explicitly analyzed. We shall discuss this issue further in Section 6.

[15] Our analysis extends to situations where D2 and U2 belong to a vertically integrated firm, or where λ is higher when U1 supplies D2. These possibilities, which could strengthen the strategic motive for U1 not to supply D2, are not modeled here for ease of exposition, but will be discussed later.

in U, they post instantaneous spot market prices w_1 and w_2 to the downstream producer(s).

The instantaneous demand function in D is $Q(p)$, where $Q'(p) \leq 0$. Price is the strategic variable of downstream firms, which is set at every instant after input price(s) are determined and observed. If both D1 and D2 are active, they compete by choosing prices p_1 and p_2 simultaneously. Consumers purchase from the firm with the lower price, and if the prices are equal, the firm with the lower opportunity cost makes the sale.[16]

U1's decision at $t = 0$ on whether to supply D2 may be subject to antitrust restrictions. We consider three potential antitrust policies: $\beta \in \{\beta_x, \beta_y, \beta_z\}$, where β_x refers to the requirement that U1 cannot refuse to deal with any independent downstream producer (but no restriction on the terms of trade is specified); β_y refers to the requirement that, if U1 sells to a downstream competitor (which is however not required), then w should be determined by the *efficient component pricing rule* (ECPR);[17] and β_z refers to an obligation for U1 to offer the input for sale to any downstream competitor at a price determined by ECPR.

Both α and β are assumed to have been chosen prior to $t = 0$, and we shall analyze how they affect market outcomes. Taking α and β as given parameters, we summarize the timing of the game as follows:

At $t = 0$: U1 first decides whether to incur k to innovate. If it does not, the game ends with zero payoff to all parties. Otherwise, the game continues with U1 choosing whether to offer its input for sale to D2.[18]

- If U1 chooses to supply D2, it incurs setup cost τ and posts input price w, and D2 enters the market. D2's instantaneous cost c_2 is then realized and known to both D1 and D2, after which D1 and D2 simultaneously post their instantaneous prices p_1 and p_2, and final output is produced to meet the instantaneous demand.

[16] The input prices w, w_1, and w_2, as well as the prices for the final product, p_1 and p_2, will depend on state variables such as market structures and costs, but will not directly depend on time. They are therefore not written as functions of t.

[17] As discussed in Vickers (2010) in the context of access pricing, under ECPR the w charged by U1 to D2 covers U1's direct (marginal) cost to supply D2 plus the opportunity cost (in terms of foregone profit) from doing so.

[18] If U1 is indifferent between innovation or no innovation, we assume that it chooses innovation; and if U1 is indifferent between supplying and not supplying D2, we assume that it chooses to supply D2.

- Otherwise, D2 permanently stays out of the market. D1 posts its instantaneous price, p_1.

At any $t > 0$:

- Before the arrival of U2: If only D1 is in downstream, it sets its monopoly price at every instant. If D2 is also present, U1 first sets w for D2,[19] after which D2's instantaneous cost c_2 is realized and known to both D1 and D2, who then simultaneously post p_1 and p_2.

- After the arrival of U2: If only D1 is in D, U2 posts w_2 to D1, who chooses whether to purchase from U2 or to use input from U1; D1 then sets its monopoly price at every instant t. If D2 is also in the market, U1 and U2 first simultaneously post instantaneous input prices w_1 and w_2. D2's instantaneous cost c_2 is then realized and known to both D1 and D2, who choose where to purchase the input and simultaneously post p_1 and p_2.

3. MARKET EQUILIBRIUM

This section derives equilibrium firm strategies and market structures, as well as consumer and social welfare, when there is no antitrust restriction (i.e., $\beta = \beta_o$). We first study equilibrium outcomes assuming that U1 has innovated the new input, considering in turn cases where U1 does not supply D2 and where U1 does. We then characterize equilibrium market structure, considering both U1's incentive to supply D2 and its initial incentive to innovate. Let

$$p(\tilde{c}) \equiv \arg\max_p (p - \tilde{c}) Q(p) \tag{1}$$

be the profit-maximizing price for a static monopoly with marginal cost $\tilde{c}$ facing demand $Q(p)$. Define

$$p^0 \equiv p(c); \qquad \pi^0 \equiv \left(p^0 - c\right) Q\left(p^0\right); \qquad v^0 = \int_{p^0}^{\infty} Q(p)\, dp. \tag{2}$$

[19] Alternatively, it keeps the same w from $t = 0$, until it finds optimal to change it.

We make the following assumptions to simplify analysis:

A1. For any $\tilde{c} \in [0, c]$: (i) $p(\tilde{c})$ exists uniquely and $(p - \tilde{c}) Q(p)$ increases in p for $p < p(\tilde{c})$, and (ii) $p(\tilde{c}) \geq 2\tilde{c}$.

A2. $[c - c_L] F(c) Q(c) \leq \pi^0$.

For **A1,** part (i) is standard and self-explaining, and part (ii) is satisfied if c is not too high relative to demand. **A2** is also satisfied as long as c is not too high relative to demand and/or $F(c)$ is relatively small. These two assumptions will be used in proving Lemmas 1-2 and deriving equilibrium downstream prices.[20]

3.1 Without D2 In the Downstream Market

Suppose that U1 chooses not to supply D2 at $t = 0$. Then, D2 is excluded from the market for $t \geq 0$. Before U2 arrives, M's downstream price and its profit at any t will be p^0 and π^0. After U2 arrives, U2 will optimally offer $w_2 = c - c_L$ to D1, which implies that M's instantaneous price and profit at any t will still be p^0 and π^0, whereas U2 earns instantaneous profit $\pi^0_{U2} = (c - c_L) Q(p^0)$. Thus, the instantaneous consumer welfare is always v^0, whereas the instantaneous social welfare prior to and after U2's arrival, respectively, are:

$$s^0_1 = \pi^0 + v^0; \qquad s^0_2 = \pi^0 + \pi^0_{U2} + v^0 > s^0_1. \tag{3}$$

Therefore, without selling to D2, the discounted sum of M's profit is

$$\Pi^0_M = \int_0^\infty e^{-rt} e^{-\lambda t} \left[\pi^0 + \lambda \pi^0 / r\right] dt = \frac{\pi^0 + \lambda \pi^0 / r}{r + \lambda} = \frac{\pi^0}{r}. \tag{4}$$

[20] We could simplify the model by assuming that consumers have unit demand with some reservation value, as is often done in the innovation literature. Then, both A1 and A2 are trivially satisfied when c is not too high relative to the reservation value. A general downward-slopping demand curve, as we assume here, introduces consumer gain from innovation even under monopoly, and thus permits a richer and more realistic consumer and social welfare analysis.

The discounted sums of consumer welfare and social welfare are, respectively:[21]

$$V^0 = \frac{v^0}{r}; \qquad S^0 = \frac{s_1^0 + \lambda s_2^0/r}{r+\lambda}. \tag{5}$$

We note that without D2 in the market, M's profit and consumer welfare both are independent of λ. The follow-on upstream innovation, if it is successful, does not increase consumer welfare—as the downstream monopoly price remains unchanged, but it does increase social welfare due to higher industry profit.

3.2 With D2 In the Downstream Market

Next suppose that U1 chooses to supply D2 at $t = 0$, so that D2 is in the downstream market for $t \geq 0$. We consider in turn two cases: before and after U2's arrival.

■**Equilibrium before U2's Arrival**. If U1's price for D2 is w, the opportunity cost for D1 is $w+c$. If $w+c_2 \leq \min\left\{p^0, w+c\right\}$, D2 makes the sale at price $\min\left\{p^0, w+c\right\}$; otherwise, D1 makes the sale at price $\min\left\{p^0, w+c_2\right\}$. Thus U1's profit is $wQ\left(\min\left\{p\left(w+c_2\right), p^0, c+w\right\}\right)$. Denote U1's equilibrium intermediate good price for D2 and the equilibrium downstream market price by w^a and p^a, respectively. We have:

Lemma 1 *In the presence of D2 and before the arrival of U2, $p^a = p^0$, M's instantaneous equilibrium profit is*

$$\pi_M^a = \pi^0\left[1 - F\left(p^0 - w^a\right)\right] + w^a Q\left(p^0\right) F\left(p^0 - w^a\right) > \pi^0, \tag{6}$$

where $w^a \in \left(p^o - c, p^0 - \underline{c}\right)$ solves

$$\left[\pi^0 - w^a Q\left(p^0\right)\right] f\left(p^0 - w^a\right) + Q\left(p^0\right) F\left(p^0 - w^a\right) = 0. \tag{7}$$

Because D2 sometimes has a lower (marginal) cost than D1, M can achieve a higher

[21] When no confusion would arise, in what follows we shall simply say M's profit, consumer welfare, and social welfare when referring to their respective discounted sums.

instantaneous profit by selling to D2 at an input price exceeding U1's opportunity cost $(p^0 - c)$. Since $p^a = p^0$, the presence of downstream competition in this case does not increase consumer welfare, but industry profit is higher due to both the higher profit for M, π_M^a, and the profit for D2, π_{D2}^a, where

$$\pi_{D2}^a = \int_{\underline{c}}^{p^0 - w^a} \left[p^0 - w^a - c_2\right] Q\left(p^0\right) f\left(c_2\right) dc_2 = Q\left(p^0\right) \int_{\underline{c}}^{p^0 - w^a} F\left(c_2\right) dc_2 > 0.$$

The instantaneous consumer and social welfare are $v^a = v^0$ and $s^a = \pi_M^a + \pi_{D2}^a + v^0$.

■**Equilibrium after U2's Arrival**. U1 and U2 simultaneously offer $w_1 > 0$ and $w_2 > 0$, where without loss of generality $w_2 \leq c - c_L$, because otherwise U2 would have no sales.

If $w_1 + c_2 \leq w_2 + c_L$, D2 will purchase from U1, the equilibrium downstream price will be $\min\{p(w_2 + c_L), w_1 + w_2 + c_L\}$, since D1 stands ready to purchase from U2 at $w_2 \leq c - c_L$ to supply either at price $w_1 + w_2 + c_L$ (which includes U1's opportunity cost w_1 when D1 takes away the sale from D2), or at price $p(w_2 + c_L)$, whichever is smaller. Both U1 and D2 will earn positive profits. Furthermore, since $w_2 + c_L \leq c$, from **A1** we have $p(w_2 + c_L) \geq 2(w_2 + c_L)$; and since $2(w_2 + c_L) > (w_1 + w_2 + c_L)$, it follows that $p(w_2 + c_L) > w_1 + w_2 + c_L$. The equilibrium price in D is thus $p^b = w_1 + w_2 + c_L$.

On the other hand, if $w_1 + c_2 > w_2 + c_L$, D2 will purchase from U2 at w_2, the equilibrium price in D will be $p^b = w_2 + c_L$, since D1, observing c_2 and knowing that D2 will purchase from U2, stands ready to purchase from U2 at w_2 and to sell to final consumers at price $w_2 + c_L$. Both M and D2 earn zero while U2 earns positive profit.[22]

Notice that since $c_2 \geq c_L$ by assumption, in equilibrium $w_1 \leq w_2$, otherwise M and D1 will always earn zero profit (in which case w_1 is not optimal). Thus, denoting the equilibrium input prices of U1 and U2 by w_1^b and w_2^b, we have $w_1^b \leq w_2^b \leq c - c_L$, and the equilibrium

[22] If D2 could commit to purchasing its input from U1 at price w_1, then D2 could price its product at $w_1 + w_2 + c_L$, which could lead to positive profits for U1 and D2 even if $w_1 + c_2 > w_2 + c_L$. Without such a commitment, however, it is only optimal for D2 to purchase from the supplier with a lower total cost, and knowing that, D1 and D2 will engage in Bertrand price competition leading to price $w_2 + c_L$.

downstream market price is

$$p^b = \begin{cases} w_1^b + w_2^b + c_L & if \quad w_1^b + c_2 \leq w_2^b + c_L \\ w_2^b + c_L & if \quad w_1^b + c_2 > w_2^b + c_L \end{cases}. \tag{8}$$

The expected instantaneous profits for M (through U1) and U2 are:

$$\begin{aligned} \pi_M (w_1, w_2) &= w_1 F (w_2 - w_1 + c_L) Q (w_1 + w_2 + c_L), \\ \pi_{U2} (w_1, w_2) &= w_2 [1 - F (w_2 - w_1 + c_L)] Q (w_2 + c_L). \end{aligned} \tag{9}$$

The equilibrium $w_1^b > 0$ and $w_2^b > 0$ are assumed to exist and to satisfy first-order conditions $\partial \pi_M (w_1, w_2) / \partial w_1 = 0$ and $\partial \pi_{U2} (w_1, w_2) / \partial w_2 = 0$.[23] Denote the equilibrium instantaneous profit for M, U2, and D2, as well as consumer and social welfare by π_M^b, π_{U2}^b, π_{D2}^b, v^b, and s^b, respectively. Then:

Lemma 2 *(i)* $\pi_M^a > \pi^o > \pi_M^b$; *(ii)* $p^b < p^o = p^a$, $v^b > v^a = v^o$; *(iii)* $s^b > s^a > s_1^o$; *and (iv)* $\pi_{U_2}^b > \pi_{U2}^o$ *and* $s^b > s_2^o$ *if*

$$[1 - F (c)] Q (c) \geq Q (p^o), \tag{10}$$

but $s^b < s_2^o$ *if* $\| Q' (p) \| \to 0$ *for* $p \leq p^o$.

When D1 is a downstream monopoly, M can maintain industry monopoly profit (π^o) through vertical control even when there is upstream competition. But when D2 is also present, M can no longer attain the original monopoly profit when facing competition in U ($\pi_M^b < \pi^0$). Thus, despite $\pi_M^a > \pi^0$, if the follow-on innovation in U is likely, U1 will prefer not to supply D2.

The presence of D2 lowers downstream market price, increasing U2's sales. But it also lowers U2's price, due to competition from U1. Condition (10), which would be satisfied if demand is not too inelastic and c not too high, ensures that the output effect dominates so that $\pi_{U_2}^b > \pi_{U2}^0$.

[23] For example, if $c = 0.5$, $F (c_2) = c_2$ on $[0, 1]$, $Q (p) = 2 - p$, and $c_L = 0$, then $w_1^b = 0.222\,72$ and $w_2^b = 0.492\,14$.

Instantaneous social welfare is the highest in the presence of both D2 and U2, is lower without U2, and is the lowest without both D2 and U2, as industry production costs increase in the order of these market structures. The comparison between s^b and s_2^0, instantaneous social welfare in the presence of both U2 and D2 and that when U2 is present but D2 is not, is generally ambiguous. With U2 in the market, the presence of D2 lowers equilibrium downstream price, which has a positive impact on output and social welfare, but it sometimes causes final output to be produced using U1's input, resulting in higher production cost, which has a negative impact on social welfare. The positive "output expansion" effect on social welfare dominates when condition (10) holds, whereas the negative "output diversion" effect dominates if $\|Q'(p)\| \to 0$ for $p \leq p^0$.[24]

If U1 chooses to supply D2 at $t = 0$, M's post-innovation equilibrium profit, consumer welfare, and social welfare are respectively:

$$\Pi_M^d = \frac{\pi_M^a + \lambda \pi_M^b / r}{r + \lambda} - \tau; \qquad V^d = \frac{v^o + \lambda v^b / r}{r + \lambda}; \qquad S^d = \frac{s^a + \lambda s^b / r}{r + \lambda} - \tau, \tag{11}$$

where Π_M^d decreases in λ but V^d increases in λ, with the effect of λ on S^d generally ambiguous.

3.3 Equilibrium Market Structure and Innovation

We now determine the equilibrium market structure and M's innovation decision. First, we ask when U1 will choose to supply D2 in a market equilibrium, given its innovation. Comparing Π_M^0 and Π_M^d from (4) and (11), recalling $\pi_M^a > \pi^0 > \pi_M^b$, and noticing that π_M^a, π^0, and π_M^b are all finite and independent of τ and λ, we immediately have:

Proposition 1 *U1 will supply D2 if and only if*

$$\frac{\left(\pi_M^a - \pi^0\right)}{(r + \lambda)} - \frac{\lambda \left(\pi^0 - \pi_M^b\right)}{r (r + \lambda)} \geq \tau. \tag{12}$$

[24] Reduction of social welfare due to entry can also occur in other models, but it is often due to the existence of entry cost (e.g., Mankiw and Whinston, 1986) Here the entry of D2 can reduce social welfare even when there is no entry cost, because it results in the use of a less efficient input.

In particular, as $\lambda \to 0$, *U1 will supply D2 if* $\tau < \left(\pi_M^a - \pi^0\right)/r$ *but not if* $\tau > \left(\pi_M^a - \pi^0\right)/r$; *and as* $\tau \to 0$, *U1 will supply D2 if* $\lambda < \bar{\lambda}$ *but not if* $\lambda > \bar{\lambda}$, *where*

$$\bar{\lambda} \equiv r\left(\pi_M^a - \pi^0\right) / \left(\pi^0 - \pi_M^b\right). \tag{13}$$

Therefore, when there is no potential competition for U1's IP (i.e., $\lambda \to 0$), U1 will supply D2 so long as the setup cost to do so is not too high. In this case, U1 increases profit by supplying D2, since it can share some of the surplus created when D2 has lower cost. On the other hand, if potential competition from U2 is sufficiently likely ($\lambda > \bar{\lambda}$), U1 will not supply D2 even if there is little fixed cost to do so. Thus, it is the potential competition from the creation of alternative IP, not competition among IP users, that may motivate refusal to deal.

Notice that if supplying D2 leads to a higher λ, then condition (12) will be more difficult to hold.[25] We thus have:

Remark 1 *U1 will have a stronger incentive for refusal to deal if supplying D2 raises* λ.

There are several possible reasons why presence of D2 may make the follow-on innovation more likely, or λ higher for any given α. One possibility is that D2 might obtain technical information from U1, which could have a positive spillover effect on U2's follow-on innovation. Alternatively, because the presence of D2 tends to increase U2's profit from the follow-on innovation, U2 is more likely to bring the innovation to the market if doing so involves some fixed cost.

We next compare consumer and social welfare with or without D2. Consumer surplus is higher with D2 than without D2, because the arrival of U2 benefits consumers only when D2 is present (recall $v^b > v^a - v^0$ from Lemma 2). However, as $\lambda \to 0$, consumer welfare under the two market structures becomes approximately the same, as can be seen from (5) and (11). When (10) holds, the presence of D2 increases instantaneous social welfare, and hence also increases social welfare if transaction cost τ is small; but U1's supplying D2

[25] Recall that Π_M^0 is independent of λ while Π_M^d decreases in λ. Hence, in condition (12), λ corresponds to the arrival rate of follow-on innovation when D2 is present in the downstream market.

would reduce social welfare when τ is high enough, as is apparent from (11). We thus have:

Proposition 2 *(i)* $V^d > V^0$*, and* $V^d \to V^0$ *as* $\lambda \to 0$*. (ii)* $S^d > S^0$ *if* $\tau \to 0$ *and (10) holds, but* $S^d < S^0$ *if* τ *is large enough.*

Finally, we consider U1's initial innovation decision in the input market. U1 will innovate if and only if $k \leq \max\left\{\Pi_M^o, \Pi_M^d\right\}$. Thus, innovation will occur if k is not too large. Let Ω be any set of parameter values and define the indicator function

$$I_\Omega = \begin{cases} 1 & \text{if the parameter values belong to } \Omega \\ 0 & \text{otherwise} \end{cases}. \tag{14}$$

Then, without antitrust restriction on U1, in equilibrium M's profit, consumer welfare, and social welfare are respectively:

$$\begin{aligned} \Pi_M^* &= I_{\Pi_M^d \geq \max\left\{\Pi_M^0, k\right\}} \left(\Pi_M^d - k\right) + I_{\left\{\Pi_M^0 \geq k\right\} \cap \left\{\Pi_M^0 > \Pi_M^d\right\}} \left(\Pi_M^0 - k\right), \\ V^* &= I_{\Pi_M^d \geq \max\left\{\Pi_M^0, k\right\}} V^d + I_{\left\{\Pi_M^0 \geq k\right\} \cap \left\{\Pi_M^0 > \Pi_M^d\right\}} V^0, \\ S^* &= I_{\Pi_M^d \geq \max\left\{\Pi_M^0, k\right\}} \left(S^d - k\right) + I_{\left\{\Pi_M^0 \geq k\right\} \cap \left\{\Pi_M^0 > \Pi_M^d\right\}} \left(S^0 - k\right). \end{aligned} \tag{15}$$

4. WELFARE EFFECTS OF ANTITRUST POLICIES

We now consider the three potential antitrust policies that restrict the exercise of IPRs by U1: β_x, β_y, and β_z. These restrictions can potentially affect both U1's incentives to create the intellectual property and the post-innovation market outcomes.

First, under β_x, U1 is required to supply D2 but there is no restriction on U1's pricing. Denote M's profit, consumer welfare and social welfare under β_x by Π_M^x, V^x and S^x.We have:

$$\Pi_M^x = I_{\Pi_M^d \geq k} \left(\Pi_M^d - k\right); \qquad V^x = I_{\Pi_M^d \geq k} V^d; \qquad S^x = I_{\Pi_M^d \geq k} \left(S^d - k\right). \tag{16}$$

Proposition 3 *Holding everything else constant: (i)* $V^x \lesseqgtr V^*$ *if* $\lambda \to 0$ *or if* τ *is large enough;* $V^x < V^*$ *and* $S^x < S^*$ *if* τ *is large enough and* $k \leq \Pi_M^0$*. (ii)* $V^x > V^*$ *if* $\lambda > \bar{\lambda}$

while k and τ are both sufficiently small, and $S^x > S^*$ if in addition (10) holds.

If follow-on innovation is sufficiently unlikely, consumer welfare will be roughly the same with or without the presence of D2. Forcing U1 to supply D2 by β_x, however, could cause U1 to switch from innovation to no innovation, resulting in (substantial) losses to both consumer and social welfare. On the other hand, if $\lambda > \bar{\lambda}$, U1 would choose to supply D2 only under β_x, and, when k and τ both small enough, U1 will indeed supply D2 under β_x, implying that β_x increases consumer welfare. On social welfare, there is the additional complication that the presence of D2 generally has ambiguous impact due to the conflicting output expansion and diversion effects. If (10) holds, however, instantaneous social welfare is higher in the presence of D2, and thus β_x improves social welfare when the other conditions are satisfied. Notice that β_x can increase social welfare only when it would *reduce* M's equilibrium profit.

Next, under β_y, U1, when it is the only upstream seller and chooses to supply D2, is required to charge D2 no more than $w = p^0 - c$.[26] In this case, if U1 supplies D2, M's instantaneous profit is π^0 before the arrival of U2 and $\pi_M^b < \pi^0$ thereafter. Thus, M is always better off not to supply D2, which will be its equilibrium choice. If $\max\left\{k, \Pi_M^0\right\} > \Pi_M^d$, then β_y will have no effect on consumer and social welfare. But if $\max\left\{k, \Pi_M^0\right\} \leq \Pi_M^d$, U1 would have supplied D2 without β_y, and thus β_y reduces consumer welfare since $V^0 < V^d$; and if additionally (10) holds so that $s^0 < s^d$, then β_y also reduces social welfare. Denote the consumer welfare and social welfare under β_y by V^y and S^y, respectively, we thus have:

Proposition 4 *(i) $V^y \leq V^*$; and $V^y < V^*$ if $\max\left\{k, \Pi_M^0\right\} \leq \Pi_M^d$. (ii) Suppose that (10) holds. Then, $S^y \leq S^*$; and $S^y < S^*$ if $\max\left\{k, \Pi_M^0\right\} \leq \Pi_M^d$.*

Thus, ECPR (weakly) reduces consumer welfare, and it also (weakly) reduces social welfare if (10) holds. It is important to note that antitrust policies may change the equilibrium market structure, which is determined endogenously in our model. ECPR leads to lower consumer and social welfare in our model, not only because it may discourage innovation

[26] This assumes that under ECPR, w does not incorporate U1's possible fixed setup cost τ.

by reducing innovation returns, but also because it can result in a post-innovation market structure that is unfavorable to consumer and social welfare.

Finally, under β_z, if U1 is the upstream monopoly supplier, U1 will be required to supply D2 at price $w^z = p^o - c$, the downstream equilibrium price is p^o, and instantaneous profits for M and D2 are respectively $\pi_M^{za} = \pi^0 < \pi_M^d$ and

$$\pi_{D2}^{za} = \int_{\underline{c}}^{c} (c - c_2) Q\left(p^0\right) f(c_2) \, dc_2 > \pi_{D2}^a,$$

with instantaneous consumer and social welfare $v^{za} = v^0$ and $s^{za} \equiv \pi^0 + \pi_{D2}^{za} + v^0 > s^a$. After U2's arrival, the outcome is the same as under β_x. Let

$$\hat{\Pi}_M^z \equiv \frac{\pi^0 + \lambda \pi_M^b / r}{\lambda + r} - \tau; \quad \Pi_M^z = I_{\hat{\Pi}_M^z \geq k} \left(\Pi_M^d - k\right);$$

$$V^z = I_{\hat{\Pi}_M^z \geq k} \frac{v^0 + \lambda v^b}{\lambda + r}; \quad S^z = I_{\hat{\Pi}_M^z \geq k} \left(\frac{s^{za} + \lambda s^b / r}{\lambda + r} - \tau\right), \tag{17}$$

where Π_M^z, V^z, and S^z denote M's profit, consumer surplus, and social surplus at the equilibrium under β_z. Similarly as under β_x, we have:

Proposition 5 *Holding everything else constant: (i) $V^z \lesseqqgtr V^*$ if $\lambda \to 0$ or if τ is large enough; $V^z < V^*$ and $S^z < S^*$ if τ is large enough and $k \leq \Pi_M^o$. (ii) $V^z > V^*$ if k and τ are both small enough but $\lambda > \hat{\lambda}$, and $S^z > S^*$ if in addition (10) holds.*

If a follow-on innovation in U is sufficiently unlikely, consumer welfare would be roughly the same with or without the presence of D2. If τ is large, U1 would innovate only if it does not supply D2. In both cases, β_z could lower consumer and social welfare by causing U1 to abandon innovation, similarly as β_x. On the other hand, if k and τ are both small enough but λ is high enough, U1 will innovate under β_z, and β_z also changes the post-innovation market structure from downstream monopoly to downstream duopoly, with the latter providing higher consumer welfare, and, if in addition (10) holds, also higher social welfare.

While β_y is clearly dominated by β_o in terms of consumer welfare (and also of social welfare if (10) holds), both β_x and β_z can either raise or lower consumer and social welfare. The relative desirability of β_x and β_z depends on the welfare measures. Given U1's innovation, consumer welfare is the same under β_x and β_z, while social welfare is higher under β_z than under β_x (due to higher production efficiency under β_z). But since M's post-innovation profit is higher under β_x than under β_z, the initial innovation incentive is higher under the former. We thus have:

Corollary 1 *(i)* $V^x \geq V^z$; *and* $V^x > V^z$ *for a set of intermediate values of* k. *(ii)* $S^x < S^z$ *if* k *is sufficiently small, but* $S^x \geq S^z$ *for a set of intermediate values of* k.

Therefore, among the three antitrust policies, β_x results in (weakly) higher consumer welfare than either β_y or β_z.[27] Social welfare, however, can be either higher or lower under β_x than under β_z.

Furthermore, if competition is only among potential (downstream) IP users ($\lambda \to 0$), then none of the three potential antitrust policies would benefit consumers, and they may substantially reduce consumer welfare, by causing U1 either to abandon the innovation, or to switch to a market structure with lower post-innovation consumer welfare.

5. COORDINATION OF IP PROTECTION AND ANTITRUST

We now endogenize the strength of IP protection, α. Antitrust and IP protection both can potentially increase consumer welfare and possibly also social welfare. We are interested in how they can be optimally coordinated to achieve this policy objective. In particular, should antitrust and IP protection be substitutes or complements? That is, does the optimal strength in one policy increase or decrease in the strength of the other policy? For antitrust policies, we shall only consider β_x and β_z, as β_y is (weakly) dominated by no antitrust restriction.

Since $\lambda'(\alpha) < 0$ in our model, stronger IP protection, or a higher α, implies that follow-on innovation by U2 is less likely. If the downstream market structure is duopoly, then

[27] Again, this is because restricting input prices through ECPR does not lower the downstream monopoly price for final consumers, but can hurt consumers when the reduced profit of the innovating firm due to the restriction causes the firm to abandon the innovation.

$$\frac{\partial \Pi_M^d}{\partial \alpha} = \frac{\pi_M^b - \pi_M^a}{(r+\lambda)^2}\lambda'(\alpha) > 0, \quad \frac{\partial V^d}{\partial \alpha} = \frac{v^b - v^0}{(r+\lambda)^2}\lambda'(\alpha) < 0, \quad \frac{\partial S^d}{\partial \alpha} = \frac{s^b - s^a}{(r+\lambda)^2}\lambda'(\alpha) < 0.$$

M's profit is higher with stronger IP protection when there is downstream competition, because stronger IP protection delays the expected arrival of the upstream competitor and prolongs M's monopoly in the input market. This, however, reduces consumer and social welfare. Thus stronger IP protection here involves the usual trade-off between providing innovation incentive and increasing post-innovation consumer and social welfare.

On the other hand, if D1 is a downstream monopoly, then

$$\frac{\partial \Pi_M^0}{\partial \alpha} = 0; \quad \frac{\partial V^0}{\partial \alpha} = 0; \quad \frac{\partial S^0}{\partial \alpha} = \frac{\pi_{U2}^0}{(r+\lambda)^2}\lambda'(\alpha) < 0.$$

When M has monopoly position in the downstream market, its profit (Π_M^0) is not reduced by the arrival of an upstream competitor. Thus, changes in α, which only affects λ (or how fast U2 is expected to arrive), have no effect on M's profit.[28] Since D1 will charge the same monopoly price to final consumers, with or without U2, consumer welfare is also not affected by α. Industry profit is higher after U2's arrival, due to lower production cost, and thus a higher α that delays the arrival of U2 reduces social welfare.

The result below describes how α affects consumer and social welfare as well as how the effects may depend on antitrust restrictions.

Proposition 6 *(i) Consumer welfare and/or social welfare decreases in* α *if* k *is sufficiently small. (ii) Without antitrust restriction, consumer welfare increases in* α *if the higher* α *results in the change from* $\Pi_M^d < \max\left\{\Pi_M^0, k\right\}$ *to* $\Pi_M^d \geq \max\left\{\Pi_M^0, k\right\}$*; under* β_x *or* β_z*, consumer and social welfare increase in* α *if the higher* α *results in the change from* $\Pi_M^d < k$ *to* $\Pi_M^d \geq k$ *or from* $\hat{\Pi}_M^z < k$ *to* $\hat{\Pi}_M^z \geq k$*, respectively.*

[28] For convenience, we have maintained the assumption that upstream firms post prices to downstream producers, which gives all the bargaining power to the upstream firms. More realistically, when D1 is the only firm downstream, it may also have some bargaining power. Then, Π_M^o would actually be *higher* if IP protection (α) is lower, as M could share some of the efficiency gains due to the arrival of U2.

Without antitrust restrictions, a higher α can reduce consumer and social welfare by delaying the follow-on innovation, but it can potentially increase consumer and social welfare in two ways: increasing innovation incentive (when the downstream market has a duopoly), and making it more likely that U1 will choose to supply D2 post innovation (so that the downstream market is a duopoly).

If there is antitrust restriction that prohibits refusal-to-deal, with or without the additional requirement of ECPR, then the potential welfare benefit of a higher α is reduced, because it no longer has the potential benefit to motivate U1 to supply D2, since the antitrust restriction has already ensured a downstream duopoly, if U1 innovates. In this sense, restrictive antitrust can partially substitute for strong IP protection.

Interestingly, strong IP protection can also partially substitute for antitrust restriction, as in the following:

Proposition 7 *Suppose that $\lambda \to 0$ when $\alpha \to 1$ and $\lambda > \hat{\lambda}$ when $\alpha < \hat{\alpha}$ for some $\hat{\alpha} \in (0, 1)$. Then: (i) When $\alpha \to 1$, antitrust, in the form of β_x or β_z, has little or negative impact on consumer welfare (i.e., $V^x \lessapprox V^*$, $V^z \lessapprox V^*$). (ii) When $\alpha < \hat{\alpha}$, antitrust, in the form of β_x or β_z, will increase consumer welfare if k and τ are small enough, and will also increase social welfare if additionally (10) holds.*

When IP protection is strong enough, U1 has little concern for future competition from potential follow-on innovation. U1 thus has no anticompetitive motive to exclude D2—it will choose to supply D2 to achieve a higher profit if the fixed cost to supply D2, τ, is relatively small. Furthermore, due to U1's monopoly upstream price, the final prices for consumers are the same with or without downstream competition, and thus antitrust has little benefit to consumers even if it does not cause reduction in innovation, but will substantially lower consumer welfare if it causes U1 to abandon the innovation.[29]

When IP protection is relatively weak, U1 is likely to face future competition from the

[29] Even without an anticompetitive motive, U1's decision on whether to supply D2 may not maximize social welfare, as U1 does not internalize D2's profit. But the purpose of antitrust is not to protect or benefit competitors. Furthermore, an antitrust liability for U1 to supply D2 could also reduce welfare if the resulting lower profit discourages U1 to innovate.

follow-on innovation. U1 thus has an anticompetitive motive to exclude D2—to maintain its monopoly profit through D1's vertical control with respect to the upstream market. In such situations, antitrust policies that prohibit refusal-to-deal, with or without the additional requirement of ECPR, will increase consumer welfare, provided that k and τ are small enough so that innovation still occurs. The social welfare effects of the antitrust policies are generally ambiguous, even when they do not stifle innovation and even when $\tau \to 0$, because the instantaneous social welfare could be higher under downstream monopoly than under duopoly. The additional condition (10) ensures a positive social welfare effect when k and τ are sufficiently small.

It is important to recognize that IPRs grant the IP holder certain exclusive rights, including the right to charge a monopoly price for the intermediate good embedding the IP. In this sense, refusal to deal by the input monopolist, when it is motivated by cost considerations, should not be considered as anticompetitive in the usual sense, even if it does exclude downstream competition. But to the extent that there can be follow-on innovation that does not infringe the current monopolist's IPRs, as is determined by IP laws, conduct by the monopolist that has the purpose of deterring future competition from follow-on innovation would be anticompetitive. However, even in the latter case, the consumer and social welfare effects of prohibiting refusal to deal can be ambiguous, partly due to its effects on innovation and partly also because there can be other motives. As we have demonstrated, policies on IP protection and antitrust each has costs and benefits; economic analysis can shed light on how to optimally coordinate them. For example, when IP protection is strong, the danger from the "false positive" of imposing an antitrust liability on refusal to deal is high, which reduces the desirability of such a policy.

We conclude this section with the following summary:

Remark 2 *When innovation is for an intermediate good, IP protection and antitrust tends to be substitutes as policy instruments: strong IP protection is less desirable in the presence of restrictive antitrust policy, and, conversely, restrictive antitrust policy is also less desirable if IP protection is strong.*

Put differently, a free-market approach that imposes no antitrust restrictions is more likely to be optimal when IP protection is strong, whereas restrictive antitrust is more likely to be beneficial when IP protection is weak.

6. DISCUSSIONS

We next discuss some of the modeling assumptions, possible extensions, and case examples that our theory potentially sheds light on.

6.1 Vertical Contracting

Our model assumes that upstream firm(s) make linear price offers to downstream producers. This subsection extends the analysis to situations where firms can use general vertical contracting to maximize profits. In particular, we consider instantaneous two-part tariff contracts specifying both a unit price (w) and a fixed fee (T), possibly also with a long-term exclusive-dealing clause, that maximize industry profit. For convenience, assume that the upstream firm(s) will make contract offers, with the downstream firm(s) receiving the disagreement (reservation) payoff.

First, suppose that D1 is the only downstream seller. Then after its arrival, U2 will offer equilibrium contract $(\tilde{w}^o, T^o) = (0, \pi(c_L) - \pi^o)$, where $\pi(c_L) \equiv [p(c_L) - c_L] Q(p(c_L))$; $\tilde{w}^o = 0$ maximizes industry profit, and T^o allows U2 to extract maximum payment from D1, subject to D1's reservation profit π^o.

Next, suppose that U1 supplies to D2 at $t = 0$. In this case the results depend on whether exclusive-dealing clauses are allowed. When such clauses are not feasible, then the main insights of our model continue to be valid under two-part tariff contracts. Specifically, M's instantaneous profit is the lowest in the presence of both D2 and U2, is higher without D2, and is the highest with D2 but without U2. Consequently, U1 will supply D2 when λ and τ are small but not when λ and/or τ is large, again having the two motives as in the main model. Prior to U2's arrival, U1 will offer D2 $\tilde{w}^a \leq p^o - c$ together with some T^a to extract surplus from D2. Thus β_y will be irrelevant, whereas β_x (or β_z) will still affect consumer and social welfare through (possibly conflicting) effects on innovation incentives and post-innovation market outcomes.[30]

On the other hand, if exclusive-dealing clauses are feasible, then U1 will no longer have the anticompetitive motive to refuse to supply D2. After U2's arrival, an exclusive-dealing contract between U2 and D1, with input price $\tilde{w}^b = 0$, will achieve maximum (collusive) industry profit $\pi(c_L)$ under final price $p(c_L)$, and thus in equilibrium U2 will contract with D1 even if D2 is present to compete for U2's business.[31] The disagreement payoff of D1, however, may be affected by the potential competition from D2. If D2 is not allowed to purchase from U2 by some earlier contract with U1, then D1's disagreement payoff in its contract with U2 is π^o; if D2 is free to purchase from U2, then competition between D1 and D2 for U2's exclusive contract will drive D1's disagreement payoff to zero.

Thus, at $t = 0$, U1 has the incentive to offer D2 a contract requiring D2 to purchase exclusively from U1 at unit price $\tilde{w}^a$ and instantaneous fixed fee T^a, which U1 can choose to terminate at some future time, where $\tilde{w}^a \leq p^o - c$ maximizes instantaneous industry profit. If U1 can offer such an exclusive contract, then it will do so as long as the discounted sum of industry profit is higher with D2 than without D2 before the arrival of U2, and U1's decision to supply D2 will then no longer be influenced by the potential future competition of U2. Notice that since D2 will not receive positive profit after U2's arrival, as U2 will contract with D1 to achieve higher joint profit, U1 needs to offer little compensation to D2 at $t = 0$ for D2 to agree to the exclusive contract.

To summarize: If firms can engage in exclusive-dealing contracting, then U1 no longer has the anticompetitive motive to refrain from supplying D2 at $t = 0$; instead, U1 will have the incentive to use exclusive-dealing contracts to achieve monopoly outcomes through collusion.

[30] Our analysis may also be applied to situations where the two markets produce complementary products in general.

[31] As Chen and Riordan (2007) observed, a vertically integrated firm is more capable of achieving collusion with a competitor through an exclusive-dealing contract than a vertically separated firm.

6.2 Downstream Entry Conditions

Our analysis has assumed that D2 will not be in the market if U1 does not supply it at $t = 0$. One possibility for this is that production with U1's technology is necessary for D2 to be cost effective in using the input from a follow-on innovation. Alternatively, there might be high opportunity cost for D2 to remain in the market or enter again at some future time, if it does not produce early on.

Now suppose that U1 is unable to exclude D2, or suppose that there will be other downstream entrants in the future. In either case, U1 would have no anticompetitive motive not to supply D2, provided that λ is not affected by selling to D2; and by choosing its price optimally U1 can potentially increase profit if the presence of D2 brings in efficiency gains to the industry. U1 might still choose not to supply D2 if it is not cost efficient to do so, possibly due to high fixed cost to supply D2. It is also possible that U1 will not supply D2 even when D2 brings in efficiency gains, if U1's pricing is for some reason constrained or if the bargaining between U1 and D2 is such that U1 does not benefit from supplying D2. In such situations, however, an antitrust obligation for U1 to supply D2 could either reduce cost efficiency or further weaken U1's bargaining position, which could unduly reduce U1's innovation incentive.

6.3 Nature of Potential Upstream Competition

We have assumed that there is only one potential follow-on innovation, to focus on how future competition for U1's IP may affect U1's incentive to supply a downstream rival and the welfare effects of IP protection and antitrust. Our analysis can be extended to situations where there are additional follow-on innovations. When such potential future upstream competitors are more likely to appear, there will be more incentive for U1 not to supply D2 in order to maintain monopoly power for the industry through vertical control. Furthermore, similar results will obtain if a follow-on innovation, when it arrives, is costly to implement.

To consider the effects of both IPRs and antitrust policies, we have assumed that potential future competition comes from a follow-on innovation, so that its probability to occur depends on IP protection for U1's initial innovation. But the dependence of λ on α is not essential for our arguments; our insights on why U1 may refuse to deal with D2 and on the welfare effects of prohibiting such conduct would still be valid if λ is given exogenously. Even if the initial monopoly position of U1 is due to its possession of some unique physical assets, acquired through its investment, and there is a possibility that another upstream firm may acquire competing physical asset in the future, similar strategic considerations would be present. Our analysis thus has implications more generally for policies concerning property rights and antitrust. We focus on innovation and IP, however, because the ex-ante and ex-post welfare tension is most striking in the case of IP, and because the potential interaction/coordination between policies on IP and antitrust is especially important in many industries where innovation drives market performance.

6.4 Case Examples

Our analysis has identified two potential motives for an input monopolist to refuse to supply an independent downstream firm. A strategic motive may arise when there is potential upstream competition in the future, and the downstream dominance achieved through refusal to deal enables the monopolist to maintain monopoly profit via vertical control even when the upstream market will become competitive. This strategic motive is stronger if supplying the independent downstream firm increases the likelihood of upstream competition in the future. On the other hand, refusal to deal can also be motivated by cost or efficiency considerations, such as high setup cost to supply the independent downstream firm and bargaining failures. The following case examples, despite their apparent differences from our stylized model, serve to illustrate our ideas.

Both motives identified in our analysis are potentially relevant for the EU *Microsoft* case, where the Court of First Instance confirmed the European Commission's finding that Microsoft had abused its dominance in PCs operating systems by refusing to supply interoperability information to its competitors in the work group server operating systems market.[32] Such information was considered essential for competitors' server operating systems to function effectively in operation with ubiquitous Window-based client PCs. But if the competitors' server operating systems potentially offered higher value to some consumers, Microsoft could have shared the efficiency gains by licensing the interoperability information under copyright protection. So why did Microsoft refuse to do so? One possibility, as our analysis suggests, is that by not supplying and potentially excluding the downstream competitors, Microsoft could reduce the threat of competition from rival PC operating systems in the upstream market, or maintain industry dominance even if the rival systems become successful. However, it is also possible that Microsoft was unable to charge a licensing fee that would sufficiently compensate it for the potential costs involved and its potential loss of revenue in the server operating systems market. While refusal to deal under either possibility could harm competition in the downstream server market, the legal standard established by the Court's decision and its welfare implications do depend on what might have been the motive(s).

Refusal to deal can be motivated by strategic considerations in the upstream market even when the monopolist does not directly compete in the downstream market. For example, on June 8, 1998, the U.S. Federal Trade Commission filed a complaint against Intel, a dominant firm in the PC microprocessor market, alleging that Intel illegally refused to deal with computer makers Compaq, Intergraph, and DEC, who possessed patents in rival microprocessor and related technologies. The complaint alleged that Intel refused to provide technical information about Intel products for the purpose of forcing those customers to grant Intel licenses to microprocessor-related technology developed and owned by those customers, which "... effectively undermine the patent rights of such firms and reduce their incentives to develop new technologies relating to microprocessors".[33] The FTC and Intel reach a proposed settlement on March 8, 1999, in which Intel promised not to withhold any technical information customarily furnished to microprocessor chip customers.

Some important refusal-to-deal cases occurred in aftermarkets. In *Xerox*, for example, the

[32] Microsoft v Commission, T-201/04, 2007. Microsoft was also found to have engaged in another abusive conduct by tying the Windows PC operating system with Windows Media Player.

[33] *In the Matter of Intel Corporation, FTC Docket No. 9288.*

durable-good producer refused to sell patented replacement parts and copyrighted service manuals to competitors in the copier repair market. The literature on refusal to deal in aftermarkets has explained why a firm may want to monopolize the aftermarket, for reasons ranging from exploiting locked-in consumers to avoiding inefficiencies in consumers' choice of maintenance services.[34] This literature, however, typically assumes that the service providers in the aftermarket have equal costs. When other service providers have lower costs, which seems plausible in some situations, it is less clear why the repair parts monopolist would choose refusal to deal instead of supplying the competing service providers to share potential efficiency gains. Since the input monopolist also produces the durable good, the copier, potential future competition for the patented repair parts seems less likely to be a major concern. Instead, transaction costs and/or the inability to charge monopoly prices for the replacement parts might have motivated refusal to deal by the input monopolist.

7. CONCLUSION

At the center of policy discussions concerning property rights and antitrust is the issue of whether a monopolist, equipped with IP from innovation to produce an intermediate good, should have an antitrust liability to supply competitors. In this paper, I have developed an analytical framework to address this issue, starting from clarifying why the monopolist, who could increase short-term profits from supplying an efficient downstream competitor, may choose refusal to deal instead. Anticompetitive refusal to deal may occur, but only when potential upstream competition from a follow-on innovation is likely: By not supplying the downstream competitor, the monopolist may either make the follow-on innovation less likely, or achieve monopoly vertical control even if the upstream market becomes competitive in the future.

The consumer and social welfare effects of imposing an antitrust liability to supply, however, are generally ambiguous. This is partly because the reduction of monopoly profit under a restrictive antitrust policy would reduce innovation incentive, and partly also be-

[34] See Carlton and Waldman (2009) for a detailed discussion of the literature.

cause refusal to deal can be motivated by other considerations including avoiding high transaction costs. By disentangling the anticompetitive and cost motives, I identify sufficient conditions under which prohibiting refusal to deal would raise or lower consumer and social welfare. Notably, restricting monopoly pricing for the intermediate good alone cannot possibly benefit consumers.

IP protection and a restrictive antitrust policy towards refusal to deal each has costs and benefits. My analysis shows that they can be optimally coordinated to benefit consumers through their impact on innovation incentives and post-innovation market performance. In particular, a free-market approach that imposes no antitrust restriction is more beneficial under strong IP protection, whereas restrictive antitrust policies become more desirable when IP protection is weak.

APPENDIX

Proof of Lemma 1. We first show that $w^a + c \geq p^0$. Suppose to the contrary that $w^a + c < p^0$. Then $\min\left\{p^0, w + c\right\} = w + c$ and

$$\begin{aligned}\pi_M(w) &= \int_c^{\bar{c}} \left(p^0 - c\right) Q\left(p^0\right) f(c_2)\, dc_2 + \int_{\underline{c}}^{c} wQ\left(p^0\right) f(c_2)\, dc_2 \\ &< \pi^0 \left[1 - F(c)\right] + \left(p^0 - c\right) Q\left(p^0\right) F(c) = \pi^0.\end{aligned}$$

That is, M's profit can be increased by raising w from w^a to $p^0 - c$, a contradiction.

Next, from **A1,** $p^0 - c \geq c$ and $p\left(p^0 - c + c_2\right) \geq p(c) = p^0$. Thus $p^a = \min\left\{p(w + c_2), p^0\right\} = p^0$.

U1's profit-maximizing price w^a maximizes the profit of the vertically integrated firm, M:

$$\begin{aligned}\pi_M(w) &= \int_{p^0 - w}^{\bar{c}} \left(p^0 - c\right) Q\left(p^0\right) f(c_2)\, dc_2 + \int_{\underline{c}}^{p^0 - w} wQ\left(p^0\right) f(c_2)\, dc_2 \\ &= \pi^0 \left[1 - F\left(p^0 - w\right)\right] + wQ\left(p^0\right) F\left(p^0 - w\right)\end{aligned}$$

for $w \in \left[p^0 - c,\ p^0 - \underline{c}\right]$, or w^a solves $\pi_M'(w^a) = 0$ given by (7), where $\pi_M'\left(p^0 - c\right) > 0$

and $\pi_M'\left(p^0 - \underline{c}\right) < 0$, implying that $p^0 - c < w^a < p^0 - \underline{c}$. It follows that $w^a Q\left(p^0\right) > \pi^0$, and hence $\pi_M^0 = \pi_M\left(w^a\right) > \pi^0$. ■

Proof of Lemma 2. (i) From (6), $\pi_M^a > \pi^0$. Next, if $w_1^b + w_2^b + c_L \leq c$,

$$\begin{aligned}\pi_M^b &= \left[w_1^b + w_2^b + c_L - \left(w_2^b + c_L\right)\right] F\left(w_2^b - w_1^b + c_L\right) Q\left(w_1^b + w_2^b + c_L\right) \\ &\leq \left[c - \left(w_2^b + c_L\right)\right] F\left(w_2^b - w_1^b + c_L\right) Q\left(c\right) < \left[c - c_L\right] F\left(c\right) Q\left(c\right) \leq \pi^0,\end{aligned}$$

where the first inequality follows from $\left(p - \tilde{c}\right) Q\left(p\right)$ increasing in p for $p < p\left(\tilde{c}\right)$ and $p\left(w_2^b + c_L\right) > p\left(0\right) \geq c$ by **A1**, and the second inequality follows from **A2**. On the other hand, if $w_1^b + w_2^b + c_L > c$,

$$\pi_M^b = w_1^b F\left(w_2^b - w_1^b + c_L\right) Q\left(w_1^b + w_2^b + c_L\right) < \left[c - c_L\right] F\left(c\right) Q\left(c\right) \leq \pi^0,$$

where the first inequality follows from $w_1^b \leq w_2^b \leq c - c_L$, $w_2^b - w_1^b + c_L < c$, and $F'\left(\cdot\right) > 0$ but $Q'\left(\cdot\right) \leq 0$; and the second inequality follows from **A2**.

(ii) Since $w_1^b + c_L \leq w_2^b + c_L \leq c$, we have $w_1^b + w_2^b + c_L < 2c \leq p\left(c\right) = p^0 = p^a$. It follows that $p^b \leq w_1^b + w_2^b + c_L < p^0 = p^a$, and $v^b > v^a = v^0$.

(iii) The true marginal cost of production in the presence of U2 is $c_L < \min\left\{c, c_2\right\}$ for $c_2 > w_2^b + c_L - w_1^b$ and c_2 for $c_2 \leq w_2^b + c_L - w_1^b < c$. Thus production cost in the presence of U2 is lower than that without U2. This, together with $p^b \leq w_1^b + w_2^b + c_L < p^0 = p^a$, implies that $s^b > s^a$, and $s^a = \pi_M^a + \pi_{D2}^a + v^0 > s_1^0 = s^0 = \pi^0 + v^0$.

(iv)

$$\begin{aligned}\pi_{U2}^b &= \pi_{U2}\left(w_1^b, w_2^b\right) = w_2^b\left[1 - F\left(w_2^b - w_1^b + c_L\right)\right] Q\left(w_2^b + c_L\right) \\ &\geq \left(c - c_L\right)\left[1 - F\left(c - c_L - w_1^b + c_L\right)\right] Q\left(c - c_L + c_L\right) \text{ (since } w_2^b \text{ is optimal for U2)} \\ &= \left(c - c_L\right)\left[1 - F\left(c - w_1^b\right)\right] Q\left(c\right) > \left(c - c_L\right)\left[1 - F\left(c\right)\right] Q\left(c\right) \text{ (since } w_1^b > 0\text{)} \\ &\geq \left(c - c_L\right) Q\left(p^0\right) = \pi_{U2}^0 \text{ (from condition (10)).}\end{aligned}$$

$$
\begin{aligned}
s^b &= F\left(w_2^b - w_1^b + c_L\right)\left[w_1 Q\left(w_1^b + w_2^b + c_L\right) + \int_{w_1^b + w_2^b + c_L}^{p^0} Q(p)\,dp\right] \\
&\quad + \left[1 - F\left(w_2^b - w_1^b + c_L\right)\right]\left[w_2^b Q(w_2 + c_L) + \int_{w_2^b + c_L}^{p^0} Q(p)\,dp\right] + \int_{p^0}^{\infty} Q(p)\,dp \\
&\quad + w_1 Q\left(w_1^b + w_2^b + c_L\right) F\left(w_2^b - w_1^b + c_L\right) + Q\left(w_1^b + w_2^b + c_L\right)\int_{\underline{c}}^{w_2^b - w_1^b + c_L} F(c_2)\,dc_2
\end{aligned}
$$

$$
\begin{aligned}
&> F\left(w_2^b - w_1^b + c_L\right)\left[2w_1 Q\left(w_1^b + w_2^b + c_L\right) - \left(w_2^b + w_1^b\right) Q\left(p^0\right)\right] + \left(p^0 - c_L\right) Q\left(p^0\right) \\
&\quad + \int_{p^0}^{\infty} Q(p)\,dp + [1 - F(\cdot)]\left[w_2^b\left[Q\left(w_2^b + c_L\right) - Q\left(p^0\right)\right] + \int_{w_2^b + c_L}^{p^0}\left[Q(p) - Q\left(p^0\right)\right] dp\right]
\end{aligned}
$$

$$
\begin{aligned}
&> -F\left(w_2^b - w_1^b + c_L\right)\left(w_2^b - w_1^b\right) Q\left(p^0\right) + \left(p^0 - c_L\right) Q\left(p^0\right) + \int_{p^0}^{\infty} Q(p)\,dp \\
&\quad + \left[1 - F\left(w_2^b - w_1^b + c_L\right)\right]\left[w_2^b\left[Q\left(w_2^b + c_L\right) - Q\left(p^0\right)\right] + \int_{w_2^b + c_L}^{p^0}\left[Q(p) - Q\left(p^0\right)\right] dp\right].
\end{aligned}
$$

Thus, $s^b > s_2^0 = \left(p^0 - c_L\right) Q\left(p^0\right) + \int_{p^0}^{\infty} Q(p)\,dp$ if

$$
[1 - F(w_2 - w_1 + c_L)]\, w_2^b\left[Q(w_2 + c_L) - Q\left(p^0\right)\right] \geq F(w_2 - w_1 + c_L)\left(w_2^b - w_1^b\right) Q\left(p^0\right),
$$

which holds if

$$
[1 - F(w_2 - w_1 + c_L)]\, Q(w_2 + c_L) \geq Q\left(p^0\right),
$$

which, since $w_2 + c_L \leq c$, holds if $[1 - F(c)]\, Q(c) \geq Q\left(p^0\right)$.

On the other hand, if $\|Q'(p)\| \to 0$ for $p \leq p^0$, $s^b \to$

$$
F\left(w_2^b - w_1^b + c_L\right)\left(w_1 - w_2^b\right) Q\left(p^0\right) + \left[p^0 - c_L\right] Q\left(p^0\right) + Q\left(p^0\right)\int_{\underline{c}}^{w_2^b - w_1^b + c_L} F(c_2)\,dc_2 + \int_{p^0}^{\infty} Q(p)\,dp
$$

$$
\begin{aligned}
&< \left[p^0 - c_L\right] Q\left(p^0\right) + \left(c_L - \underline{c}\right) F\left(w_2^b - w_1^b + c_L\right) Q\left(p^0\right) + \int_{p^0}^{\infty} Q(p)\, dp \\
&\leq \left[p^0 - c_L\right] Q\left(p^0\right) + v^0 = s_2^0.
\end{aligned}
$$

■

Proof of Proposition 3. (i) If $\lambda \to 0$, then $V^x = I_{\Pi_M^d \geq k} V^d \to I_{\Pi_M^d \geq k} V^0 \leq I_{\max\left\{\Pi_M^o, \Pi_M^d\right\} \geq k} V^0 \leq V^*$. If τ is large enough, then $\Pi_M^d < k$ and $V^x = I_{\Pi_M^d \geq k} V^d = 0 \leq V^*$. Furthermore, if τ is large enough and $k \leq \Pi_M^0$, we have $\Pi_M^d < k \leq \Pi_M^0$, in which case $V^x = 0 < V^0 = V^*$ and $S^x = 0 < S^0 = S^*$. (ii) If k and τ are both small enough but $\lambda > \bar{\lambda}$, then $k \leq \Pi_M^d < \Pi_M^0$, and hence $V^x = V^d > V^0 = V^*$; if in addition (10) holds, then $S^d > S^0$, and hence $S^x = S^d > S^0 = S^*$. ■

Proof of Proposition 6. (i) If k is sufficiently small, U1 will innovate. The result then follows from that both V^d and S^d decrease in α, whereas V^0 is not affected by changes in α but S^0 decreases in α. (ii) Without antitrust restriction, if the increase in α causes a switch from $\Pi_M^d < \max\left\{\Pi_M^0, k\right\}$ to either $\Pi_M^d \geq \Pi_M^0 \geq k$ or $\Pi_M^d \geq k > \Pi_M^0$, then the increase in α increases consumer welfare since $V^d > V^0 > 0$. (It also increases social welfare when (10) holds.) On the other hand, consumer and social welfare are zero under β_x if $\Pi_M^d < k$ and zero under β_z if $\hat{\Pi}_M^z < k$. Thus, if an increase in α causes $\Pi_M^d \geq k$ under β_x or $\hat{\Pi}_M^z \geq k$ under β_z, then consumer and social welfare are higher under the higher α. ■

Proof of Proposition 7. (i) When $\alpha \to 1$, $\lambda \to 0$. Thus, from (11), and (17), when $\alpha \to 0$, $V^d \to V^0$ and $V^z \to V^0 \approx V^d$. If $\min\left\{\Pi_M^d, \hat{\Pi}_M^z\right\} \equiv \hat{\Pi}_M^z \geq k$, U1 will innovate with or without β_x or β_z; and if $k > \max\left\{\Pi_M^d, \Pi_M^0\right\}$, U1 will not innovate with or without β_x or β_z. For these cases $V^x \approx V^*$, $V^z \approx V^*$. But if $\Pi_M^0 \geq k > \Pi_M^d$, then $V^x < V^*$ and $V^z < V^*$. (ii) When $\alpha < \hat{\alpha}$, $\lambda > \hat{\lambda}$ and $\Pi_M^0 > \Pi_M^d$. Thus, if k and τ are small enough, $V^x = V^z = V^d > V^0 = V^*$, whereas $S^* = S^0 - k$ and $S^x = S^d - k < S^z$. Thus, if in addition (10) holds, which implies $S^d > S^0$, we have $S^z > S^x > S^*$. ■

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