Refusal to Deal, Intellectual Property Rights, and Antitrust

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June 2011

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Revised October 2012

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.

*I thank two referees, the Editor, Shiyuan Pan, Patrick Rey, Mike Riordan, Marius Schwartz, Guofu Tan, Mike Waldman, participants of a seminar at Cornell University (March 2011), the Workshop on IO and Competition Policy at Shanghai University of Finance and Economics (June 2011), and the Competition Policy Workshop at the Toulouse School of Economics (October 2012) for helpful comments and suggestions.

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 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. But this only adds to the puzzle: if a monopolist can extract surplus from supplying a downstream rival, why would it refuse to deal?[4]

To understand the economic logic behind refusal to deal, as I shall argue, it is important 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 when future *upstream* competition from follow-

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

on innovation is (sufficiently) likely.[5]

This potential anticompetitive motive, however, should be considered in the context of other possible 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 how anticompetitive refusal to deal may occur in a dynamic setting, I next study the consumer and social welfare effects of three alternative 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 may lower consumer and social welfare when follow-on innovation is sufficiently unlikely, but can otherwise increase consumer and social welfare. Furthermore, restricting input price alone, in the form of imposing the efficient component pricing rule (ECPR), generally does not benefit consumers, 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),

[5] While I believe that this specific mechanism for anticompetitive refusal to deal, in a model of vertical industry structure and innovation, has not been idendified before, it is not a new idea that a firm may trade short-term profits for long-term gains, and the mechanism, as I shall discuss shortly, is closely related to Carlton and Waldman's (2002) original argument that product tying may protect a monopolist's primary market by detering entry in another market.

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

[7] Refusal to deal may also arise if, for instance, the monopolist is unable to engage in price discimination (or to charge monpoly prices). To the extent that this and other potential "static" reasons could render it unprofitable for the monopolist to supply its competitors even in the short run, their effects on the monopolist are similar to those from a high "transaction cost".

the strength of IP protection (as determined by IP laws) and restrictions on IP holders' conduct (as determined by antitrust laws), may interact to affect innovation incentives and 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 of a restrictive antitrust policy (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 a restrictive antitrust policy.

This research is closely 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 a 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 dynamic 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] As in Carlton and Waldman (2001), through deterring entry to the downstream market, refusal to deal in my model can protect monopoly profit from the primary (upstream) market. However, 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 in my analysis, where refusal to deal enables the input monopolist to earn monopoly industry profit even when its primary market (the upstream market) eventually becomes competitive. More importantly, I depart from the extant literatures by studying the incentives for refusal to deal with explicit consideration of innovation and IPRs, and by analyzing how to coordinate IP protection and antitrust policies.

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

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 antitrust policies restricting incumbent behavior towards *horizontally competing* entrants affect innovation incentives. By considering vertical industry competition and the interactions between IPRs and antitrust, this study introduces new considerations and complements their analysis.[9] The research is further related to the literature on vertical foreclosure (e.g., Ordover, Saloner, and Salop, 1990; Choi and Yi, 2000; Chen, 2001; and Rey and Tirole, 2005). 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 through R&D 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 $k > 0$.[10] The strength of intellectual property protection for the innovation, possibly

[9] 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.

[10] 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.

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.

The intermediate good, whose marginal cost of production for U1 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. Using the intermediate good from U1, the downstream production by D1 has constant marginal cost c_1, whereas production by D2 has constant marginal cost $c_2 < c_1$. Thus D2 is a more efficient downstream producer with U1's new technology. At $t = 0$, U1, if it innovates, chooses whether to offer its intermediate good for sale to D2. If it does, U1 incurs a one-time setup cost, $\phi \geq 0$, to make the input suitable for D2, and then posts wholesale price w to D2.[11] While w can be adjusted instantaneously at any $t > 0$, we assume that U1 commits to its decision on whether or not to supply D2, possibly due to reputation considerations or through some irreversible technical choice in its product design at $t = 0$ (as, for example, in Choi and Yi, 2000). If U1 innovates, a competitive fringe of firms in U can produce an inferior substitute to U1's product, which can be obtained by D2 to produce the final product at constant marginal cost $\bar{c} > c_1$.[12]

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 $\lambda > 0$. By using U2's input, active downstream producers, which include D1 and possibly also D2, will have a lower marginal cost of downstream production, $\underline{c}$, with $0 \leq \underline{c} < c_2$.[13] When both U1 and U2 are present in U, they simultaneously post spot market prices w_1 and w_2 to the downstream producer(s). The discount rate for all parties is r. All

[11] The setup cost may be due to technical specifications or adjustments that need to be made to the input for its use by D2. For the main model, we only consider linear input prices. We later discuss how to extend the analysis to situations where two-part tariff contracts are feasible.

[12] For convenience, we assume that the competitive fringe can produce the inferior substitute only if U1 innovates, possibly by imitating U1's technology. This allows us to normalize the payoffs of all parties to zero when U1 does not innovate. We may alternatively assume that the inferior input can be produced by D2 internally, without changing the qualitative nature of our results.

[13] The assumption that D1 and D2 have the same $\underline{c}$ is made for simplicity and is not essential for our results. We can allow D1 and D2 to have different costs using U2's input, in which case U2 can offer different input prices to D1 and D2 so that their effective marginal costs (after paying for the input) remain equalized.

firms aim to maximize the discounted sum of expected profits.

Both $\bar{c}$ and λ can be functions of α, possibly with $\bar{c} \equiv \bar{c}(\alpha)$ increasing and $\lambda \equiv \lambda(\alpha)$ decreasing, to capture the ideas that stronger IP for the initial innovation reduces potential imitation by inferior technologies and also makes follow-on innovations less likely. Later in Section 5, we shall study how α may affect market outcomes through its effects on $\bar{c}$ and λ.

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.[14]

Taking α as a given parameter chosen prior to $t = 0$, 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.[15]

- If U1 chooses to supply D2, it incurs setup cost ϕ and posts input price w; otherwise U1 commits not to supply D2. D2 then chooses either to enter or to stay out of the market. We assume that D2 will enter the market if and only if its expected post-entry profit is strictly positive. We can justify this assumption by supposing that D2 has to incur a small positive entry cost, and for ease of exposition we ignore this entry cost in the analysis.

- If D2 enters the market, D1 and D2 simultaneously post their instantaneous prices p_1 and p_2, and final output is produced to meet the instantaneous demand. If D2 stays out of the market, D1 posts its instantaneous price, p_1.

[14] 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.

[15] 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.

At Every Instant $t > 0$:

- Before the arrival of U2: If only D1 is in D, it sets its monopoly price. If D2 is also present, U1 first posts w for D2 (or keeps the same w from $t = 0$), after which D1 and D2 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. If D2 is also in the market, U1 and U2 first simultaneously post input prices w_1 and w_2. D1 and D2 then 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 structure, as well as consumer and social welfare. Let

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

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

$$p^0 \equiv p(c_1); \qquad \pi^0 \equiv \left(p^0 - c_1\right) Q\left(p^0\right); \qquad v^0 = \int_{p^0}^{\infty} Q(p)\, dp. \tag{2}$$

Recall that c_1 and c_2 are the marginal costs of D1 and D2 using the input from U1, $\bar{c}$ the marginal cost of D2 using the inferior input, $\underline{c}$ the marginal cost of D1 and D2 using input from U2, and $\underline{c} < c_2 < c_1 < \bar{c}$. We make the following assumptions:

A1: For $c \in [\underline{c}, c_1]$, $p(c)$ exists uniquely and $(p - c) Q(p)$ increases in p for $p < p(c)$.

A2: $\bar{c} < p^0 < \bar{c} - c_2 + c_1$.

A3: $p(\underline{c}) \geq c_1$ and, for $0 \leq w \leq p^0 - c_1$, $p(w + c_2) \geq w + c_1$.

A1 is standard and self-explaining. **A2** ensures that supplying D2 is potentially profitable for both U1 and D2: if U1 sells the input to D2 at price $w = \bar{c} - c_2$ and D2 is constrained not to price above p^0, U1 will receive profit $(\bar{c}-c_2)Q\left(p^0\right) > \left(p^0 - c_1\right)Q\left(p^0\right) = \pi^0$, while D2 can still have a positive markup with $p^0 - [(\bar{c} - c_2) + c_2] > 0$. **A3** ensures that in downstream Bertrand competition the firm with the higher marginal cost will be a competitive constraint so that the other firm does not price as a monopolist. These three assumptions will be used in proving Lemmas 1-2 and deriving equilibrium downstream prices.

In the following subsections, 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 it does. We then characterize equilibrium market structure, considering both U1's incentive to supply D2 and its initial incentive to innovate.

3.1 U1 Chooses not to Supply D2

Suppose that U1 chooses not to supply D2 at $t = 0$. If D2 enters the market, before the possible arrival of U2, D2's marginal cost is $\bar{c}$, whereas D1's marginal cost is $c_1 < \bar{c}$. Thus the equilibrium instantaneous price is $\bar{c}$, resulting in zero profit for D2. After U2 arrives, at every instant U2 offers D1 and D2 $w_2 = c_1 - \underline{c}$, resulting in $p_1 = p_2 = w_2$ and zero profit for both D1 and D2.[16] We thus conclude that D2 will not enter the market if U1 chooses not to supply D2.

Therefore, if U1 chooses not to supply D2, before U2 arrives, M's downstream price and its profit at any t will be p^0 and $\pi_m^{[1]} = \pi^0$.[17] After U2 arrives, U2 will optimally offer input price $w = c_1 - \underline{c}$ to D1, which implies that M's instantaneous price and profit at any t will again be p^0 and $\pi_m^{[2]} = \pi^0$, whereas U2 earns instantaneous profit $(c_1 - \underline{c})\,Q\left(p^0\right)$. The instantaneous industry profit is $\pi^0 + (c_1 - \underline{c})\,Q\left(p^0\right) = \left(p^0 - \underline{c}\right)Q\left(p^0\right)$. The instantaneous consumer welfare is always v^0, whereas the instantaneous social welfare before and after

[16] If $w_2 > c_1 - \underline{c}$, D1 can produce with its own input at unit cost c_1, while D2's price is not lower than $w_2 + \underline{c} > c_1$. Thus U2 will earn zero profit, which cannot be an equilibrium. So $w_2 \leq c_1 - \underline{c}$. However, under (**A3**), $p\left(\underline{c}\right) \geq c_1$, and hence U2 will not want to offer $w_2 < c_1 - \underline{c}$. Thus $w_2 = c_1 - \underline{c}$.

[17] We use superscript [1] to indicate that only U1 is present upstream (i.e., before U2's arrival). Superscript [2] indicates that both U1 and U2 are in the upstream market (i.e., after U2's arrival). We also use subscript m or d to indicate a downstream market where only D1 is present (monopoly) or where both D1 and D2 are present (duopoly).

U2's arrival are respectively

$$s_m^{[1]} = \pi^0 + v^0; \qquad s_m^{[2]} = \left(p^0 - \underline{c}\right) Q\left(p^0\right) + v^0 > s_m^{[1]}. \tag{3}$$

The discounted sum of social welfare is[18]

$$S_m = \int_0^\infty e^{-rt} e^{-\lambda t} \left[s_m^{[1]} + \lambda s_m^{[2]}/r\right] dt = \frac{s_m^{[1]} + \lambda s_m^{[2]}/r}{r+\lambda}.$$

In sum, without selling to D2 (in which case D1 is the downstream monopoly), M's profits, consumer welfare, and social welfare are respectively

$$\Pi_m = \pi^0/r; \quad V_m = v^0/r; \quad S_m = \frac{s_m^{[1]} + \lambda s_m^{[2]}/r}{r+\lambda}. \tag{4}$$

When D1 is the downstream monopoly, 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 the higher industry profit under lower industry costs. We note that both Π_m and V_m are independent of λ.

3.2 U2 Chooses to Supply D2

Next suppose that U1 chooses to supply D2 at $t = 0$. We show that D2 will have strictly positive post-entry profit, and it will therefore indeed choose entry in equilibrium. With D2 in the market, we consider in turn two cases: before and after U2's arrival.

■**Equilibrium before U2's Arrival**. Denote U1's price for D2 by w and D2's price by p_2. Because D2 has a lower (marginal) cost than D1, U1 can achieve a higher profit by selling to D2 at an input price exceeding U1's opportunity cost (i.e., $w > p^0 - c_1$), while D1 optimally prices at p^0 to constrain D2's price. The extent of this price "squeeze" of D2, however, is limited by the source of an inferior input that D2 may turn to, which implies

[18] 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 instantaneous or discounted sum of values, and we denote by capital letters the discounted sum of values..

that $w + c_2 \leq \bar{c}$, and the constraint is binding in equilibrium. So the equilibrium input price by U1 is $w^{[1]} = \bar{c} - c_2$, and indeed $w^{[1]} > p^0 - c_1$ from assumption **A2**. The following result, the proof of which is in the appendix, formalizes this argument.

Lemma 1 *In the presence of D2 and before the arrival of U2, in equilibrium U1 offers the input to D2 at* $w^{[1]} = \bar{c} - c_2$, *resulting in downstream price* $p_d^{[1]} = p^0$. *The instantaneous profits for M and D2 are respectively*

$$\pi_d^{[1]} = (\bar{c} - c_2) Q\left(p^0\right) > \pi^0, \quad \pi_{D2}^{[1]} = \left[p^0 - \bar{c}\right] Q\left(p^0\right) > 0. \tag{5}$$

The instantaneous consumer and social welfare are respectively $v_d^{[1]} = v^0$ *and* $s_d^{[1]} = \left(p^0 - c_2\right) Q\left(p^0\right) + v^0$, *with* $s_m^{[1]} < s_d^{[1]} < s_m^{[2]}$.

Notice that since $p_d^{[1]} = p^0$, 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, $\pi_d^{[1]} > \pi^0$, and the positive profit for D2, $\pi_{D2} > 0$.

■**Equilibrium after U2's Arrival**. With Bertrand competition between U1 and U2, at every instant U2 optimally offers D1 and D2 $w = c_2 - \underline{c}$ while U1 simultaneously offers D2 $w = 0$, with U2 making sales in equilibrium. Bertrand competition between D1 and D2 then results in equilibrium downstream price $c_2 - \underline{c}$ and zero profit for both of them. Profit for U2 is $\pi_d^{U2} = (c_2 - \underline{c}) Q(c_2)$. Profit for M, consumer welfare, and social welfare are respectively:

$$\pi_d^{[2]} = 0; \quad v_d^{[2]} = \int_{c_2 - \underline{c}}^{\infty} Q(x)\, dx > v_d^{[1]} = v^0; \quad s_d^{[2]} = (c_2 - \underline{c}) Q(c_2 - \underline{c}) + v_d^{[2]} > s_d^{[1]}. \tag{6}$$

Summarizing the above discussions and using results from Lemma 1, we have:

Lemma 2 *(i) D2's presence increases M's profit before the arrival of U2 but reduces it after U2's arrival (i.e.,* $\pi_d^{[1]} > \pi^0 > \pi_d^{[2]} = 0$*); (ii) D2's presence has no effect on price and consumer welfare before U2's arrival, but lowers price and raises consumer welfare after it (i.e.,* $p_d^{[2]} = c_2 - \underline{c} < p^0 = p_d^{[1]}$, $v_d^{[2]} > v_d^{[1]} = v^0$*); and (iii) Social welfare has the following* *ranking:* $s_d^{[2]} > s_m^{[2]} > s_d^{[1]} > s_m^{[1]}$.

When D1 is a downstream monopoly, M can maintain monopoly industry profit (π^0) 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 ($\pi_d^{[2]} = 0 < \pi^0$). Thus, despite $\pi_d^{[1]} > \pi^0$, if the follow-on innovation in U is likely, U1 will prefer not to supply D2 even if $\phi = 0$.

Social welfare is the highest in the presence of both D2 and U2, due to the lowest price and lowest industry cost. It is lower in the absence of D2, due to the downstream monopoly price under M's vertical control, even though industry cost continues to be the lowest. It is even lower with D2 but without U2, because of both downstream monopoly price and higher cost. It is the lowest when both D2 and U2 are absent, due to the further increase in industry cost.

Since D2's profit is strictly positive before U2's arrival and is zero afterwards, we conclude that D2's discounted sum of post-entry profit will be strictly positive. Hence, if U1 chooses to supply D2 at $t = 0$, D2 will indeed enter, with M's post-innovation equilibrium profit, consumer welfare, and social welfare being respectively:

$$\Pi_d = \frac{\pi_d^{[1]}}{r+\lambda} - \phi; \qquad V_d = \frac{v^0 + \lambda v_d^{[2]}/r}{r+\lambda}; \qquad S_d = \frac{s_d^{[1]} + \lambda s_d^{[2]}/r}{r+\lambda} - \phi, \tag{7}$$

where Π_d decreases in λ but V_d and S_d increase in λ.

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 $\Pi_m = \frac{\pi^0}{r}$ and $\Pi_d = \frac{\pi_d^{[1]}}{r+\lambda} - \phi$, and noticing that $\pi_d^{[1]} > \pi^0$, both of which are finite and independent of λ, we immediately have:

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

$$\frac{\pi_d^{[1]}}{r+\lambda} - \frac{\pi^0}{r} \geq \phi. \tag{8}$$

In particular, as $\lambda \to 0$, *U1 will supply D2 if* $\phi < \left(\pi_d^{[1]} - \pi^0\right)/r$ *but not if* $\phi \geq \left(\pi_d^{[1]} - \pi^0\right)/r$; *and as* $\phi \to 0$, *U1 will supply D2 if* $\lambda < \bar{\lambda}$ *but not if* $\lambda \geq \bar{\lambda}$, *where*

$$\bar{\lambda} \equiv r\left(\pi_d^{[1]} - \pi^0\right)/\pi^0. \tag{9}$$

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 efficiency gains from D2 due to its lower cost. On the other hand, if potential competition from U2 is sufficiently likely ($\lambda \geq \bar{\lambda}$), U1 will not supply D2 even if there is little fixed cost to do so.[19]

We next compare consumer and social welfare with or without the presence of D2. using (4) and (7), with $v_d^{[2]} > v_d^{[1]} = v^0$ and $s_d^{[2]} > s_m^{[2]} > s_d^{[1]} > s_m^{[1]}$ from Lemma 2, we immediately have:

Proposition 2 *(i)* $V_d > V_m$, *and* $V_d \to V_m$ *as* $\lambda \to 0$. *(ii)* $S_d > S_m$ *if* $\phi \to 0$ *but* $S_d < S_m$ *if* ϕ *is large enough.*

For (i), consumer welfare is higher when U1 deals with D2 because, while final prices are identical prior to U2's entry, after U2's entry, competition between D2 and D1 does reduce consumer prices when there is upstream competition as well. Of course, as U2's expected time of entry approaches infinity (i.e., the arrival rate $\lambda \to 0$), consumer welfare is the same whether D2 is present or not. For (ii), since the instantaneous social welfare is higher with than without D2, regardless of whether U2 is present, social welfare is higher when U1 supplies D2, provided that the setup cost for doing so is not too high.

[19] If supplying D2 raises λ, U1 will have an even stronger incentive for refusal to deal. The presence of D2 may increase λ, because, for instance, D2 might obtain technical information from U1, which could have a positive spillover effect on U2's follow-on innovation. Alternatively, the presence of D2 may increase U2's profit from the follow-on innovation, providing a higher incentive for U2 to bring it to the market if doing so involves fixed costs.

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

$$I_\Omega = \begin{cases} 1 & \text{if the parameter values belong to } \Omega \\ 0 & \text{otherwise} \end{cases}. \tag{10}$$

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

$$\begin{aligned} \Pi^* &= I_{\Pi_d \geq \max\{\Pi_m, k\}} (\Pi_d - k) + I_{\{\Pi_m \geq k\} \cap \{\Pi_m > \Pi_d\}} (\Pi_m - k), \\ V^* &= I_{\Pi_d \geq \max\{\Pi_m, k\}} V_d + I_{\{\Pi_m \geq k\} \cap \{\Pi_m > \Pi_d\}} V^0, \\ S^* &= I_{\Pi_d \geq \max\{\Pi_m, k\}} (S_d - k) + I_{\{\Pi_m \geq k\} \cap \{\Pi_m > \Pi_d\}} (S_m - k). \end{aligned} \tag{11}$$

4. WELFARE EFFECTS OF ANTITRUST POLICIES

We now consider three potential antitrust policies that restrict the exercise of IPRs by U1: β^A, β^E, and β^{AP}, which are set prior to $t = 0$. These restrictions can potentially affect both U1's incentive to create the intellectual property and the post-innovation market outcomes.

First, under β^A (superscript "A" denotes for "available"), U1 is required to supply D2 but there is no restriction on U1's pricing. It may appear that since U1 can charge D2 a prohibitively high price under β^A, the market outcome would be the same with or without the policy. However, under β^A U1 is required to make the input available and suitable for purchase by D2, which involves setup cost ϕ (e.g., configuring/providing technical information and making technical adjustment), and hence it cannot commit not to deal with D2. Consequently, if D2 does enter the market, U1 would charge D2 the *ex post* profit-maximizing price, which is generally not prohibitively high, in order to extract surplus from an efficient D2. Therefore, compared to the situation where U1 can refuse to deal, which commits U1 not to supply D2, β^A potentially has important effects on market outcomes.

Let M's profit, consumer welfare and social welfare under β^A be Π^A, V^A and S^A, respectively. Then, taking into account the innovation cost:

$$\Pi^A = I_{\Pi_d \geq k} \left(\Pi_d - k \right); \qquad V^A = I_{\Pi_d \geq k} V_d; \qquad S^A = I_{\Pi_d \geq k} \left(S_d - k \right). \tag{12}$$

Proposition 3 *(i) $V^A \lessapprox V^*$ when $\lambda \to 0$. Furthermore, $V^A \leq V^*$ and $S^A \leq S^*$ when ϕ is large enough. (ii) Suppose that $\lambda > \bar{\lambda}$. Then, if k and ϕ are both sufficiently small, $V^A > V^*$ and $S^A > S^*$.*

For (i), when follow-on innovation is sufficiently unlikely, consumer welfare is approximately the same with downstream monopoly or duopoly. Forcing U1 to supply D2 under β^A may reduce U1's innovation incentive, which can reduce consumer welfare. Furthermore, when ϕ is large, forcing U1 to supply D2 may reduce social welfare both due to the static inefficiency under high ϕ and due to the reduction in innovation incentive. For (ii), when λ is relatively large, U1 would choose to supply D2 only under β^A, and, if k and ϕ are both small enough, U1 will indeed supply D2 under β^A, implying that β^A increases both consumer and social welfare.

Next, under β^E, U1 is required to charge D2 according to the *efficient component pricing rule* (ECPR) when it is the only upstream seller and chooses to supply D2 (which is, however, not required). Thus U1 will charge D2 $w = p^0 - c_1$.[20] In this case, if U1 supplies D2, M's instantaneous profit is π^0 before the arrival of U2 and 0 thereafter. Thus, M is always better off not to supply D2, which will be its equilibrium choice. If $\max\{k, \Pi_m\} > \Pi_d$, then β^E will have no effect on consumer and social welfare. But if $\max\{k, \Pi_m\} \leq \Pi_d$, U1 would have supplied D2 without β^E, in which case β^E reduces both consumer and social welfare since $V_m < V_d$ and, with $\Pi_m \leq \Pi_d$, $S_m < S_d$. Denote the consumer welfare and social welfare under β^E by V^E and S^E, respectively, we thus have:

Proposition 4 *$V^E \leq V^*$ and $S^E \leq S^*$, with $V^E < V^*$ and $S^E < S^*$ if $\max\{k, \Pi_m\} \leq \Pi_d$.*

Therefore, ECPR (weakly) reduces consumer and social welfare. Importantly, antitrust

[20] 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.

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 by reducing innovation returns, but also because it can result in a post-innovation market structure that is unfavorable to consumer and social welfare.[21]

Finally, under β^{AE}, U1 cannot refuse to supply D2, and, if U1 is the upstream monopoly supplier, it is also required to charge D2 no more than $w^{AE} = p^o - c_1$. Then, before U2's arrival, U1 will charge D2 w^{AE}. From assumption **A3**, $p\left(w^{AE} + c_2\right) \geq w^{AE} + c_1 = p^0$. Hence the downstream equilibrium price is p^o, profit for M is π^0 $(< \pi_d^{[1]})$, and profit for D2 before U2's arrival is

$$\left[p^0 - \left(w^{AE} + c_2\right)\right] Q\left(p^0\right) = \left(c_1 - c_2\right) Q\left(p^0\right).$$

Consumer and social welfare are respectively $v^{AE} = v^0$ and

$$s^{AE} = \pi^0 + \left(c_1 - c_2\right) Q\left(p^0\right) + v^0 = \left(p^0 - c_2\right) Q\left(p^0\right) + v^0 = s_d^{[1]}.$$

After U2's arrival, the outcome is the same as under β^A, so that M has zero profit, while instantaneous consumer and social welfare are respectively $v_d^{[2]}$ and $s_d^{[2]}$. The discounted sums of profit for M, consumer welfare, and social welfare at the equilibrium under β^{AE} are thus:

$$\Pi^{AE} = I_{\frac{\pi^0}{\lambda+r} - \phi \geq k}\left[\frac{\pi^0}{\lambda + r} - \phi - k\right]; \quad V^{AE} = I_{\frac{\pi^0}{\lambda+r} - \phi \geq k} V_d; \quad S^{AE} = I_{\frac{\pi^0}{\lambda+r} - \phi \geq k}\left(S_d - k\right). \tag{13}$$

We have:

Proposition 5 *(i) $V^{AE} < V^*$ and $S^{AE} < S^*$ if either $\frac{\pi^0}{r} < k \leq \frac{\pi_d^{[1]}}{r+\lambda} - \phi$ or $\frac{\pi^0}{\lambda+r} - \phi < k \leq \frac{\pi^0}{r}$. (ii) $V^{AE} > V^*$ and $S^{AE} > S^*$ if $\lambda > \hat{\lambda}$ while k and ϕ are both sufficiently small.*

[21] The somewhat surprising result here about the negative effects of β^E should be interpreted with caution. If D2 cannot commit to refusal to deal, then ECPR can potentially result in lower prices for consumers. Also, as we shall argue next, if the policy is used together with prohibiting refusal to deal, then it can increase consumer and social welfare.

For (i), without β^{AE}, M can extract surplus from D2 and have a higher profit than not supplying D2 if ϕ and λ are small, in which case M's higher profit may motivate it to innovate. When M is unable to extract surplus from D2 under β^{AE}, the lower profit reduces M's innovation incentive and causes M to abandon the innovation for some intermediate k values. It is also possible that k is not so high to deter innovation when M does not supply D2, but ϕ is high enough so that M would not innovate if it is required to supply D2. In both cases the policy reduces consumer and social welfare. For (ii), if k and ϕ are both small enough but λ is relatively high, U1 will innovate under β^{AE}, and β^{AE} also changes the post-innovation market structure from downstream monopoly to downstream duopoly, with the latter providing higher consumer and social welfare.

While β^{E} is dominated by no antitrust restriction in terms of both consumer and social welfare, β^{A} and β^{AE} can either raise or lower consumer and social welfare. To evaluate the relative desirability of β^{A} and β^{AE}, we compare (12) and (13). Notice that given U1's innovation, the two policies produce the same consumer and social welfare. However, since M's post-innovation profit is higher under β^{A} than under β^{AE} (i.e., $\Pi_d = \frac{\pi_d^{[1]}}{r+\lambda} - \phi > \frac{\pi^0}{\lambda+r} - \phi$), innovation incentive is higher under β^{A}. We thus conclude:

Corollary 1 *$V^A \geq V^j$ and $S^A \geq V^j$ for $j = E$ and AE, where the strictly inequalities hold if $\frac{\pi^0}{\lambda+r} - \phi < k \leq \frac{\pi_d^{[1]}}{r+\lambda} - \phi$.*

Thus, in our setting, it would be optimal either to have β^{A} or to impose no antitrust restriction on refusal to deal.[22] These findings, however, rely on the specifics of our model and should therefore be interpreted with caution. In particular, the seemingly odd result that consumer welfare is always weakly greater under β^{A} than under β^{AE} depends on the nature of the competition between D1 and D2. Because of Bertrand competition for a homogeneous product, reducing the input price to D2 doesn't affect final prices. If there were some product differentiation, this would not be the case. In general, one might expect

[22] 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.

a reduction in input prices to passed on to consumers under β^{AE}.

5. COORDINATION OF IP PROTECTION AND ANTITRUST

We now endogenize the strength of IP protection, α. We are interested in how antitrust and IP protection can be optimally coordinated to achieve the policy objective of increasing consumer and social welfare. 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? We shall focus on the comparison between β^A and no antitrust restriction (the comparison between β^{AE} and no antitrust restriction is somewhat similar). For the analysis in this section, we assume that $\bar{c} \equiv \bar{c}(\alpha)$ increases in α, and $\lambda \equiv \lambda(\alpha)$ decreases in α.

If only D1 is present in the downstream market, then, from (4),

$$\frac{\partial \Pi_m}{\partial \alpha} = 0; \quad \frac{\partial V_m}{\partial \alpha} = 0; \quad \frac{\partial S_m}{\partial \alpha} = \frac{s_m^{[2]} - s_m^{[1]}}{(r+\lambda)^2} \lambda'(\alpha). \tag{14}$$

If both D1 and D2 are present in the downstream market, then, from (5) and (7),

$$\frac{\partial \Pi_d}{\partial \alpha} = \left[\frac{\bar{c}'(\alpha)}{r+\lambda} - \frac{(\bar{c} - c_2)\lambda'(\alpha)}{(r+\lambda)^2} \right] Q\left(p^0\right); \quad \frac{\partial V_d}{\partial \alpha} = \frac{v_d^{[2]} - v^0}{(r+\lambda)^2} \lambda'(\alpha); \quad \frac{\partial S_d}{\partial \alpha} = \frac{s_d^{[2]} - s_d^{[1]}}{(r+\lambda)^2} \lambda'(\alpha). \tag{15}$$

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

Proposition 6 *Assume $\bar{c}'(\alpha) > 0$ and $\lambda'(\alpha) < 0$. (i) Consumer welfare and social welfare (weakly) decrease in α if k and ϕ are sufficiently small, with or without β^A. (ii) Without antitrust restriction, consumer welfare increases in α if the higher α results in the change from $\Pi_d < \max\{\Pi_m, k\}$ to $\Pi_d \geq \max\{\Pi_m, k\}$; with β^A, consumer and social welfare increase in α if the higher α results in the change from $\Pi_d < k$ to $\Pi_d \geq k$.*

Stronger IP protection, or a higher α, can potentially affect market outcomes through both $\bar{c}(\alpha)$ and $\lambda(\alpha)$. First, with $\bar{c}'(\alpha) > 0$ and $\lambda'(\alpha) < 0$, a higher α increases profit from the initial innovation (i.e., U1's profit), by raising $\bar{c}(\alpha)$ and by delaying the possible arrival of U2. Hence a higher α increases the incentive for the initial innovation but hinders the follow-on innovation. Second, regarding consumer and social welfare, if D2 is not present in the downstream market, then equilibrium downstream price will always be p^0, thus an increase in α has no effect on post-innovation consumer welfare but reduces post-innovation social welfare by delaying the follow-on innovation. If D2 is present in the downstream market, a higher α reduces both consumer and social welfare after innovation, since it enables U1 to raise price to D2 in the absence of U2 by increasing $\bar{c}(\alpha)$ and it delays the follow-on innovation by lowering $\lambda(\alpha)$. However, since a higher α increases profit from the initial innovation, it can increase consumer and social welfare by bringing about an innovation that might otherwise not happen.

Therefore, without antitrust restriction (β^A), a higher α can reduce consumer and social welfare by resulting in higher prices and 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 after innovation (so that the downstream market is a duopoly). If an antitrust policy is in place that prohibits refusal-to-deal, 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 policy already ensures a downstream duopoly when 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 $\alpha \to 1$, β^A has little or negative impact on consumer welfare (i.e., $V^A \lessapprox V^*$). (ii) When $\alpha < \hat{\alpha}$, β^A will increase both consumer and social welfare if k and ϕ are sufficiently small.*

For (i) in Proposition 7, 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, ϕ, is 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.

For (ii) in Proposition 7, when IP protection is relatively weak, U1 is likely to face future competition from the follow-on innovation. U1 thus has an anticompetitive motive to exclude D2—to maintain its monopoly profit through D1's vertical control for the upstream market. In such situations, antitrust policy that prohibits refusal-to-deal will increase both consumer and social welfare, provided that k and ϕ are small enough so that innovation still occurs.

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 viewed 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 cost-based 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 1 *When innovation is for an intermediate good, IP protection and antitrust can be substitutes as policy instruments: strong IP protection may be less desirable in the presence* *of a restrictive antitrust policy, and, conversely, a restrictive antitrust policy may be less desirable if IP protection is strong.*

Put differently, a free-market approach that imposes no antitrust restriction 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.[23,24]

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 with Two-Part Tariffs

Our model assumes that upstream firms 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 disagreement (reservation) payoffs.

First, suppose that D1 is the only downstream seller. Then after its arrival, U2 will offer equilibrium tariffs $(\tilde{w}^o, T^o) = (0, \pi(\underline{c}) - \pi^o)$, where $\pi(\underline{c}) \equiv [p(\underline{c}) - \underline{c}]\, Q(p(\underline{c}))$, $\tilde{w}^o = 0$ 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

[23] I thank Patrick Rey for suggesting this interpretation of the result.

[24] It is important to note that the conclusion here might be special to the particulars of the model. For example, U2's innovation time in the model does not depend on its profits from entry. If it did, then β^A could raise λ by increasing the expected profit from the innovation, which might make it a partial substitute for weak (not strong) IP protection in some ways.

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 ϕ are small but not when λ and/or ϕ is large, again having the two motives as in the main model. Thus, since prior to U2's arrival U1 will offer D2 $w = 0$ and an optimal T to extract surplus, β^E will be irrelevant, whereas β^A (or β^{AE}) will still affect consumer and social welfare through (possibly conflicting) effects on innovation incentives and post-innovation market outcomes.

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 $w = 0$, will achieve maximum (collusive) industry profit $\pi(\underline{c})$ under final price $p(\underline{c})$, and thus in equilibrium U2 will contract with D1 even if D2 is present to compete for U2's business.[25] 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 that maximizes instantaneous industry profit, which U1 can choose to terminate at some future time. 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

[25] 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.

incentive to use exclusive-dealing contracts to achieve monopoly outcomes through collusion.

6.2 Downstream Market Conditions

To simplify analysis, we have assumed that the downstream firms produce a homogeneous good and have deterministic costs. The equilibrium price and profits are then obtained straightforwardly from Bertrand competition. This allows us to illustrate the main ideas of the paper most transparently.

One possible variation of the model is to introduce cost uncertainties. For instance, with U1's input, D1 or/and D2 have uncertain costs, so that sometimes D1 has a cost advantage and sometimes D2 does. Then, instead of having D2 always be the lower cost firm and D1 only act as a competitive constraint, each of them will make sales in certain portion of the time. The qualitative nature of our results will still hold in this case, except that the more efficient firm may not always be the successful seller and hence the presence of D2 need not always improve efficiency.[26] Alternatively, D1 and D2 could produce differentiated goods, which provides another channel for U1 to extract surplus by supplying D2, with both firms producing in equilibrium. Supplying D2 could again increase profit for M prior to U2's possible arrival but decrease profit after U2's arrival. Thus U1's strategic incentive not to supply D2 still exists, in addition to the possible cost motive.

For convenience, we have not explicitly considered D2's possible entry cost. Including this cost in calculations would reduce the social welfare under the downstream duopoly market structure, but would not change our conclusions.

6.3 Nature of Potential Upstream Competition

We have made the restrictive assumption 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. Some of our analysis can be extended to situations where there are additional follow-on innovations. When such

[26] As in Chen (2011), where it is assumed that there is uncertainty in D2's cost when it uses U1's input.

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 would 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 main insights 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.[27] 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).

Some important refusal-to-deal cases occurred in aftermarkets. In *Xerox*, for example, the 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.[28] 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

[27] 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.

[28] See Carlton and Waldman (2010) for a detailed discussion of the literature.

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 might 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 because 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.

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 boost consumer welfare through their impact on innovation incentives and post-innovation market performance. In particular, a free-market approach that imposes no antitrust restriction can be more beneficial under strong IP protection, whereas restrictive antitrust policies may become more desirable when IP protection is weak.

APPENDIX

Proof of Lemma 1. First, the equilibrium downstream price will be $\min\left\{p^0, w+c_1\right\}$, with D2 making the sale if $w+c_2 \leq \min\left\{p^0, w+c_1\right\}$, and D1 making the sale otherwise. To see this, we argue as follows: If $p^0 \geq w+c_1$, then $\min\left\{p^0, w+c_1\right\} = w+c_1$, which is the marginal opportunity cost of D1 when U1's potential income is taken into account, and the result follows from Bertrand Nash equilibrium where the equilibrium price is the higher marginal cost of the two homogeneous producers.[29] If $p^0 < w+c_1$, D1 has higher profit selling at price p^0 than at any higher price, and hence it optimally sets $p_1 = p^0$, which becomes the equilibrium price.

Second, in equilibrium we must have $w+c_1 \geq p^0$ so that the equilibrium downstream price is p^0. Suppose not, then $w+c_1 < p^0$, in which case $p_2 = \min\left\{w+c_1, p\left(w+c_2\right)\right\}$. Then, from assumption **A3,** $p_2 = w+c_1$, and D2 will make the sale since $c_2 < c_1$. But then from **A1** M's profit is

$$wQ\left(w+c_1\right) = \left(w+c_1-c_1\right) Q\left(w+c_1\right) < \left(p^0-c_1\right) Q\left(p^0\right).$$

Hence, recalling that $p^0 - c_1 < \bar{c}$ from assumption **A2,** M's profit can be increased by raising w to $w = p^0 - c_1$, a contradiction.

Finally, in equilibrium U1 chooses w to maximize $wQ\left(\min\left\{p^0, w+c_1\right\}\right) = wQ\left(p^0\right)$, subject to the constraint that $w + c_2 \leq \bar{c}$. Since $wQ\left(p^0\right)$ increases in w, the optimal w for U1 is $w^{[1]} = \bar{c} - c_2$, and M's instantaneous equilibrium profit is $\pi_d^{[1]} = \left(\bar{c}-c_2\right) Q\left(p^0\right)$. Since from **A2** $\bar{c} < p^0 < \bar{c} - c_2 + c_1$, we have $p^0 - c < \bar{c} - c_2$. Hence $\pi_d^{[1]} > \pi^0$ and $\pi_{D2}^{[1]} = \left[p^0 - \bar{c}\right] Q\left(p^0\right) > 0$. Since the price in D is p^0, instantaneous consumer welfare is $v_d^{[1]} = v^0$, and, with instantaneous industry profit being $\left(p^0 - c_2\right) Q\left(p^0\right) > \pi^0$, instantaneous social welfare is $s_d^{[1]} = \left(p^0 - c_2\right) Q\left(p^0\right) + v^0$. Therefore $s_m^{[1]} = \pi^0 + v^0 < s_d^{[1]} < \left(p^0 - \underline{c}\right) Q\left(p^0\right) + v^0 = s_m^{[2]}$. ■

Proof of Proposition 3. (i) When $\lambda \to 0$, from (4) and (7), $V_d \approx V_m$. If $\Pi_d \geq \Pi_m$,

[29] As is typically assumed in the literature, at the Bertrant Nash equilibrium a firm will not set a price at which it perfers not to make any sales (e.g., Chen and Riordan, 2007).

then $V^A \approx V^*$. But if $\Pi_d < \Pi_m$, then $V^A = 0 < V^* = V_m$ if β^A causes U1 to switch from innovation to no innovation. Furthermore, when ϕ is large enough so that $\Pi_d < \Pi_m$, if in addition $k > \Pi_m$, then there will be no innovation and hence $V^A = V^* = 0$ and $S^A = S^* = 0$; but if instead $k \leq \Pi_m$, β^A would cause U1 to switch from innovation to no innovation, with $V^A = 0 < V^* = V_m$ and $S^A = 0 < S^* = S_m$. (ii) When $\lambda > \bar{\lambda}$, U1 will choose not to supply D2. If k and ϕ are both sufficiently small, $V^A = V_d$ and $S^A = S_d - k$, while $V^* = V_m$ and $S^* = S_m - k$. From Proposition 2, $V_d > V_m$, and $S_d > S_m$ if ϕ is sufficiently small. ■

Proof of Proposition 5. (i) From (4) and (7), $\Pi_m = \frac{\pi^0}{r}$ and $\Pi_d = \frac{\pi_d^{[1]}}{r+\lambda} - \phi$. Thus, if $\frac{\pi^0}{r} < k \leq \frac{\pi_d^{[1]}}{r+\lambda} - \phi$, then $\Pi_d \geq \max\{\Pi_m, k\}$ and $k > \frac{\pi^0}{\lambda+r} - \phi$. It follows that $V^{AE} = 0 = S^{AE}$ but $V^* = V_d > 0$ and $S^* = S_d - k > 0$. Also, if $\frac{\pi^0}{\lambda+r} - \phi < k \leq \frac{\pi^0}{r}$, then $V^{AE} = S^{AE} = 0$ whereas $V^* \geq V_m > 0$ and $S^* \geq S_m - k > 0$. (ii) If $\lambda > \hat{\lambda}$ while k and ϕ are both sufficiently small, then U1 will innovate with or without the policy, but will supply D2 only with the policy. Then $V^{AE} = \frac{v^0 + \lambda v_d^{[2]}/r}{\lambda+r} > \frac{v^0}{r} = V_m = V^*$, and for small enough ϕ, $S^{AE} - S^* = S_d - S_m > 0$. ■

Proof of Proposition 6. (i) If k and ϕ are sufficiently small, U1 will innovate, with or without β^A. Since $s_m^{[2]} > s_m^{[1]}$ from (3), $v_d^{[2]} > v^0$ and $s_d^{[2]} > s_d^{[1]}$ from (6), and $\bar{c}'(\alpha) > 0$ and $\lambda'(\alpha) < 0$ by assumption, we have, from (14) and (15), that V_d, S_d, and S_m all decrease in α, whereas V_m is not affected by changes in α. (ii) From (15), Π_d increases in α, whereas from (14) Π_m is not affected by α. Without antitrust restriction, if the increase in α causes a switch from $\Pi_d < \max\{\Pi_m, k\}$ to either $\Pi_d \geq \Pi_m \geq k$ or $\Pi_d \geq k > \Pi_m$, then the increase in α increases consumer and welfare since $V_d > V_m > 0$, and, when $\Pi_d \geq \Pi_m$, $S_d > S_m > 0$. On the other hand, consumer and social welfare are zero under β^A if $\Pi_d < k$. Thus, if an increase in α leads to $\Pi_d \geq k$, 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 (7), when $\alpha \to 1$, $V_d \to V_m = V^0$. If $\min \Pi_d \geq k$, U1 will innovate with or without β^A; and if $k > \max\{\Pi_d, \Pi_m\}$, U1 will not innovate with or without β^A. For these cases $V^A \approx V^*$. But if $\Pi_m \geq k > \Pi_d$, then $0 = V^A < V^*$. (ii) When $\alpha < \hat{\alpha}$, $\lambda > \hat{\lambda}$ and $\Pi_m > \Pi_d$. Then, if k and ξ are small enough, $V^A = V_d > V^0 = V^*$, and $S^A = S_d - k > S_m - k = S^*$. ■

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