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EXCLUSIVE CONTRACTS WITH COMPLEMENTARY INPUTS

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Abstract

This study constructs a model of anticompetitive exclusive contracts in the presence of complementary inputs. A downstream firm transforms multiple complementary inputs into final products. When complementary input suppliers have market power, upstream competition within a given input market benefits not only the downstream firm but also complementary input suppliers by raising complementary input prices. The downstream firm is thus unable to earn higher profits even when socially efficient entry is allowed. Hence, the inefficient incumbent supplier can deter socially efficient entry by using exclusive contracts even in the absence of scale economies, downstream competition, and relationship-specific investment.

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1 Introduction

In vertical supply chain relationships, firms often engage in contracts including vertical restraints, such as exclusive contracts, loyalty rebates, slotting fees, resale price maintenance, quantity fixing, and tie-ins.[1] Among vertical restraints, exclusive contracts have long been controversial.[2] Once signed, exclusive contracts deter efficient entrants; they thus may appear to be anticompetitive. However, scholars from the Chicago School oppose this view by arguing, based on analytic models, that rational economic agents do not sign contracts to deter more efficient entrants (Posner, 1976; Bork, 1978).[3] In rebuttals of this argument after Aghion and Bolton (1987), several researchers present market environments in which anticompetitive exclusive dealing occurs (e.g., Bernheim and Whinston, 1998). These studies introduce, for instance, scale economies in the sense that an entrant needs to trade with a certain number of buyers to offset its fixed costs (Rasmusen, Ramseyer, and Wiley, 1991; Segal and Whinston, 2000a) and downstream competition (Simpson and Wickelgren, 2007; Abito and Wright, 2008).

The present study, by taking into account complementary inputs, provides an economic environment within which anticompetitive exclusive dealing occurs. In a real-world business situation, final-good producers often transform multiple inputs into final products. More importantly, there exist complementary input suppliers with market power. In the Intel antitrust case, for example, Microsoft is a supplier with strong market power.[4] Therefore, when applying analysis of anticompetitive exclusive dealing to real-world situations, the interaction between complementary input suppliers cannot be neglected.

In this study, we develop a model of anticompetitive exclusive dealing in the presence

[1]The pioneering Rey and Tirole (1986) comprehensively considers these topics. More recently, Asker and Bar-Isaac (2014) use a repeated game to consider the matter. Excellent surveys of vertical restraints are provided by Rey and Tirole (2007) and Rey and Vergé (2008).

[2]Setting exclusive territories is a typical example of exclusive-dealing agreements. For instance, Mathewson and Winter (1984), Rey and Stiglitz (1995), and Matsumura (2003) discuss this matter.

[3]For analysis of the impact of this argument on antitrust policies, see Motta (2004) and Whinston (2006).

[4]Intel was accused of awarding rebates and various other payments to major original equipment manufacturers (e.g., Dell and HP). In a single quarter in 2007, conditional rebates and payments from Intel amounted to 76% of Dell's operating profit (Gans, 2013). See also Japan Fair Trade Commission (2005): http://www.jftc.go.jp/eacpf/cases/intel.pdf and the European Commission (2009): http://ec.europa.eu/competition/sectors/ICT/intel.html.

of complementary inputs. In our model, an upstream incumbent supplier offers an exclusive contract to a single downstream firm to deter an entrant supplier that is more efficient than the incumbent supplier—and would thus constitute a socially efficient entry. Because there are neither scale economies nor downstream competition, the incumbent supplier cannot deter socially efficient entry with exclusive contracts, as in the frameworks of previous studies. The new dimension in our model is that the downstream firm produces a final product using not only an input produced by the incumbent supplier but also a complementary input produced by a supplier with market power.

In a simple setting with linear demand and linear wholesale pricing, we first show that the existence of a complementary input supplier with market power allows the incumbent supplier to deter socially efficient entry via exclusive contracts, even in the case of a single downstream firm. To intuitively understand this result, consider the effects of socially efficient entry. Socially efficient entry into an input market generates competition, which reduces the input's price and thus allows the downstream firm to earn higher profits. Under the Chicago School argument, this effect prevents the incumbent supplier from profitably compensating the downstream firm; Chicago School scholars thus conclude that exclusion is impossible. However, when there is a complementary input supplier with market power, socially efficient entry into one input market increases the demand for the complementary input, which benefits the complementary input supplier by increasing the complementary input price. Hence, compared with the case in which there is no complementary input supplier with market power, socially efficient entry leads to a smaller increase in the downstream firm's profits. This allows the incumbent supplier to profitably compensate the downstream firm, and therefore exclusion is possible.

We also check the robustness of the above exclusion outcome and show that it can be observed in a broad range of settings. First, introducing non-linear demand, we show that the exclusion outcome results as long as the demand curve for final products is not overly convex; that is, exclusion is more likely to be observed under inelastic demand. Second, a unique exclusion equilibrium occurs in a context of non-linear wholesale pricing and a general demand function. Third, in the appendix, we show that when the inputs of incumbent and entrant suppliers are vertically differentiated, as discussed in Argenton (2010), a complementary supplier with market power is essential for deriving an exclusion equilibrium. Therefore, the exclusion outcome identified in this study can be widely applied to diverse real-world vertical relationships.

This study is related to the literature on anticompetitive exclusive contracts (Rasmusen, Ramseyer, and Wiley, 1991; Segal and Whinston, 2000a; Simpson and Wickelgren, 2007; Abito and Wright, 2008).[5] These studies share a common feature: reaching the exclusion result requires multiple downstream buyers.[6][7] In contrast, this study shows that anticompetitive exclusive contracts can be signed even under a single-buyer model.

In terms of a single-buyer model of anticompetitive exclusive contracts, this study is closest to Fumagalli, Motta, and Rønde (2012), who explore a model in which exclusive dealing can both promote relationship-specific investment and foreclose a more efficient supplier. They show that if relationship-specific investment is possible, inefficient market foreclosure occurs even in the single-buyer model because competition between suppliers diminishes the investment level of the incumbent supplier, which leaves room for the efficient supplier to set a higher input price, thereby harming the downstream buyer. In contrast, exclusion in the present study arises because a complementary input supplier directly deprives the downstream firm of some additional profits generated through competition in another complementary input market. Although a third party's rent extraction is the key factor required for deriving the exclusion outcomes in both studies, the mechanism of rent extraction in the present study is quite different from that in Fumagalli, Motta, and Rønde (2012). Moreover, the main result in

[5] In addition, certain studies examine pro-competitive exclusive dealings; e.g., non-contractible investments (Marvel, 1982; Besanko and Perry, 1993; Segal and Whinston, 2000b; de Meza and Selvaggi, 2007; de Fontenay, Gans, and Groves, 2010), industry R&D and welfare (Chen and Sappington, 2011), risk sharing (Argenton and Willems, 2012), and adverse selection (Calzolari and Denicolò, 2013). Exclusive dealing is also considered a way to solve the commitment problem posited by Hart and Tirole (1990), which arises when a single upstream firm sells to multiple retailers with two-part tariffs under unobservable contracts. See also O'Brien and Shaffer (1992), McAfee and Schwartz (1994), and Rey and Vergé (2004).

[6] In the literature on exclusion with downstream competition, Fumagalli and Motta (2006) show that the existence of participation fees to remain active in the downstream market plays a crucial role in exclusion if buyers are undifferentiated Bertrand competitors. See also Wright's (2009) study, which corrects the result of Fumagalli and Motta (2006) in the case of two-part tariffs.

[7] For extended models of exclusion with downstream competition, see Wright (2008), Argenton (2010), and Kitamura (2010, 2011). Whereas these studies all show that the resulting exclusive contracts are anticompetitive, Gratz and Reisinger (2013) show potentially pro-competitive effects if downstream firms compete imperfectly and contract breaches are possible. See also DeGraba (2013), who adapts the model to cover a situation in which a small rival that is more efficient at serving a portion of the market can make exclusive offers.

the present study does not wholly depend on the negotiation procedure between suppliers and the downstream buyer, whereas the outcome in Fumagalli, Motta, and Rønde (2012) partly depends on the negotiation procedure employed there.[8]

This study is also related to the literature on vertical relationships involving complementary inputs, such as the work of Laussel (2008), Matsushima and Mizuno (2012, 2013), and Reisinger and Tarantino (2013).[9] These studies demonstrate that vertical integration is not necessarily profitable because the complementary input supplier extracts the majority of the profits generated as a result of eliminating double marginalization through vertical integration. The present study extends this work, showing that these ideas can be applied to the literature on entry deterrence via exclusive contracts.

The remainder of this paper is organized as follows. Section 2 constructs the basic model. Section 3 presents the main results under linear wholesale pricing and extends the basic model in several dimensions. Section 4 provides analysis under non-linear wholesale pricing, while Section 5 offers concluding remarks. Appendix A presents proofs of the results. Appendixes B and C provide extended analysis.

2 Model

This section develops the basic model environment. We first explain players' characteristics and the game's timing in Section 2.1. Section 2.2 then introduces the design of the anticompetitive exclusive contracts.

2.1 Basic environment

The upstream market is composed of two complementary input markets: A and B (Figure 1). Input A is exclusively produced by supplier U_A with a constant marginal cost $c > 0$. In contrast, input B is produced by an incumbent supplier U_{IB} and an entrant supplier U_{EB}. Following the Chicago School model, U_{IB} and U_{EB} produce an identical product but with differing cost

[8] In Appendix B, we present a bargaining procedure in which the main result of our model still holds whereas that of Fumagalli, Motta, and Rønde (2012) does not.

[9] See also Arya and Mittendorf (2007) and Laussel and Long (2012).

efficiencies; namely, U_{EB} is more efficient than U_{IB}, with a constant marginal cost $c_E \in [0, c)$ as opposed to U_{IB}'s constant marginal cost $c > 0$.[10]

The downstream market is composed of a single firm. This modeling strategy clarifies the role of U_A as having market power; that is, the prevention of socially efficient entry occurs even in the absence of scale economies and downstream competition, both of which require more than one downstream firm. A downstream monopolist D transforms inputs A and B into a final product. D uses Leontief production technology: one unit of the final product is made with one unit of input A and one unit of input B:[11]

$$Q = \min\{q_A, q_B\}, \tag{1}$$

where q_i is the amount of input $i \in \{A, B\}$. Equation (1) implies that the two inputs are essential to produce a final product in a downstream market—i.e., they are perfect complements.[12] The payment for q_i units of input $i \in \{A, B\}$ is given as $w_i q_i$, where w_i is input i's price. To simplify the analysis, we assume that D incurs no production costs aside from paying for the two inputs. Thus, per unit production cost of D is given by

$$c_D = w_A + w_B.$$

We assume that the inverse demand for the final product $P(Q)$ is given by a simple linear function:

$$P(Q) = a - bQ, \tag{2}$$

where Q is the output of the final product supplied by D, $a > 2(2c - c_E)$, and $b > 0$. (In Section 4, we consider a general demand case.) The first inequality implies that U_{EB}'s monopoly price is higher than c; namely, the existence of U_{IB} always acts as a constraint on the pricing of U_{EB} when U_{EB} enters the market for input B.[13]

[10] In Appendix C, we extend the setting to a case in which the inputs are vertically differentiated, as in Argenton (2010).

[11] Introducing asymmetric production technology where one unit of the final product is made with $h > 0$ units of input A and $m > 0$ units of input B does not qualitatively change the results.

[12] Such production technology can be widely observed in real-world manufacturing. For example, producing a PC requires a CPU and an operating system, and producing a car requires a body and tires.

[13] Exclusion will still exist even when U_{EB} is more efficient, but the analysis becomes more complicated.

We assume that D cannot merge with U_A; this assumption can be justified as follows.[14] First, a vertical merger with common suppliers is sometimes prohibited by antitrust authorities because such a vertical merger can generate a foreclosure problem. Second, we can regard U_A as an industry-wide labor union of downstream firms. In the literature on oligopoly models incorporating labor unions, the labor union is usually assumed to maximize the wage level and number of employees, which can be interpreted as w_A and q_A in this study. Under this interpretation, D cannot merge with U_A.

The model contains four stages (Figure 2). In Stage 1, U_{IB} makes an exclusive offer to D with fixed compensation $x \geq 0$. D decides whether to accept the offer.[15] D immediately receives x if it accepts the offer. In Stage 2, U_{EB} decides whether to enter the market for input B. We assume that the fixed entry cost is sufficiently small that U_{EB} can earn positive profits. In Stage 3, active suppliers offer linear input prices to D. (In Section 4, we introduce non-linear pricing.) We assume that if U_{EB} enters the market for input B, then U_{IB} and U_{EB} become homogeneous Bertrand competitors. The equilibrium price of input $i \in \{A, B\}$ when D accepts (rejects) the exclusive offer is denoted by w_i^a (w_i^r) where the superscript 'a' ('r') indicates that the exclusive offer is accepted (rejected). In Stage 4, D orders inputs and sells the final product to consumers. U_k's profit in the case where D accepts (rejects) the exclusive offer is denoted by π_k^a (π_k^r), where $k \in \{A, IB, EB\}$. D's profit in the case when it accepts (rejects) the exclusive offer is denoted by π_D^a (π_D^r).

2.2 Design of exclusive contracts

For an exclusion equilibrium to exist, the equilibrium transfer x^* must satisfy the following two conditions.

First, it must satisfy individual rationality for U_{IB}; that is, U_{IB} earns higher profits under exclusive dealing:

$$\pi_{IB}^a - x^* \geq \pi_{IB}^r. \tag{3}$$

[14] See Matsushima and Mizuno (2013) for a more detailed discussion of the justifications for this assumption.

[15] Rasmusen, Ramseyer, and Wiley (1991) and Segal and Whinston (2000a) point out that price commitments are unlikely if the product's nature is not precisely described in advance. In the naked exclusion literature, it is known that if the incumbent can commit to wholesale prices, then anticompetitive exclusive dealings are enhanced. See Yong (1999) and Appendix B of Fumagalli and Motta (2006).

Second, the exclusive contract must satisfy individual rationality for D; that is, the amount of compensation x induces D to accept the exclusive offer:

$$\pi_D^a + x^* \geq \pi_D^r. \tag{4}$$

From the above conditions, it is evident that a unique exclusion equilibrium exists if and only if inequalities (3) and (4) simultaneously hold. This is equivalent to the following condition:

$$\pi_{IB}^a + \pi_D^a \geq \pi_{IB}^r + \pi_D^r. \tag{5}$$

Condition (5) implies that to determine whether anticompetitive exclusive contracts exist, we must examine whether exclusive contracts increase the joint profits of U_{IB} and D.

3 Linear wholesale pricing

This section analyzes the existence of anticompetitive exclusive contracts under linear wholesale pricing. To intuitively understand the importance of a complementary input supplier having market power, we first discuss a benchmark case in which complementary input A is competitively provided (Section 3.1). We then explore the case in which complementary input A is supplied by a monopolistic supplier and also examine how the curvature of the inverse demand function influences the result (Section 3.2). Finally, Section 3.3 discusses how market power in input market A influences the result in Section 3.2.

3.1 Benchmark: When a complementary input is competitively supplied

Assume that complementary input A is competitively provided. Then, input A's price does not depend on whether the exclusive offer is accepted in Stage 1; i.e., $w_A^a = w_A^r = c$. In this setting, the Chicago School model can be interpreted as a special case in which D can purchase complementary input A for free; i.e., $w_A^a = w_A^r = 0$.[16] Therefore, as the Chicago School argues, U_{IB} cannot deter socially efficient entry.

[16] Although a buyer is the final consumer in the Chicago School model, the result does not qualitatively change if we assume that the buyer is a downstream monopolist. See Lemma 1 of Kitamura, Sato, and Arai (2014).

Proposition 1. *Suppose that inverse demand is given by a linear function and upstream suppliers adopt linear wholesale pricing. When complementary input A is competitively provided, U_{IB} cannot deter socially efficient entry by using exclusive contracts.*

The result here can be explained using logic similar to that underlying the Chicago School argument. When D accepts the exclusive offer in Stage 1, it purchases input B from U_{IB} at a higher input price, which allows U_{IB} to earn monopoly profits. However, under linear wholesale pricing, U_{IB} and D cannot maximize their joint profits because of the double marginalization problem. Thus, the left-hand side of inequality (5) is quite small.

In contrast, when D rejects the exclusive offer in Stage 1, U_{EB} enters the market for input B in Stage 2. In Stage 3, U_{IB} and U_{EB} compete to manage D. Compared with the case of exclusive dealing, upstream competition in the B market reduces input B's price, which solves the double marginalization problem. Thus, D earns considerably higher rejection profits; that is, the right-hand side of inequality (5) becomes large. In the absence of scale economies and downstream competition, U_{IB} cannot profitably compensate D, implying that there is no x that simultaneously satisfies participation constraints (3) and (4). Therefore, when the downstream market consists of a monopolist, anticompetitive exclusive dealing cannot occur if complementary input A is competitively supplied.

3.2 When a complementary input is provided by a monopolist

We now assume that complementary input A is provided exclusively by U_A. Input A's price now depends on whether entry into the market for input B occurs, unlike in the previous subsection. As in the case in which complementary input A is provided competitively, entry into the market for input B generates competition within it, reducing input B's price. To understand the pricing behavior of U_A when input B's price decreases, we first examine the relationship between entry into the B market and input A's price. The following lemma summarizes the relationship:

Lemma 1. *When U_A has market power, socially efficient entry into the market for input B raises the equilibrium price of input A—that is, $w_A^r > w_A^a$.*

To understand this result, consider the reaction function of the monopolistic supplier of input i given input j's price w_j;

$$w_i(w_j) = \frac{a + c - w_j}{2b},$$

where $i, j \in \{A, B\}$ and $i \neq j$. It is easy to see that the strategic interaction between the two monopolistic suppliers is strategic substitute; that is, raising input A's price is the best response for U_A when input B's price decreases.[17] Therefore, entry into the market for input B induces U_A to raise input A's price and enjoy higher profits. The following proposition shows that this relationship between entry into the market for input B and input A's price allows U_{IB} to deter efficient entry by using exclusive contracts.

Proposition 2. *Suppose that inverse demand is given by a linear function and upstream suppliers adopt linear wholesale pricing. If U_A is the monopolist for input A, U_{IB} can deter socially efficient entry as a unique exclusionary equilibrium outcome.*

Note that the crucial difference as compared to the benchmark case exists in the sub-game in which D rejects the exclusive offer. As in the case in which input A is competitively supplied, entry into the market for input B generates upstream competition in this market, which benefits D. However, Lemma 1 implies that entry into this market also benefits U_A by increasing input A's price, which prevents D from earning considerably higher profits upon rejecting the exclusive offer; that is, the right-hand side of inequality (5) does not become sufficiently large. This allows U_{IB} to profitably compensate D using its profits under exclusive dealing. Therefore, the existence of a complementary supplier with market power leads to anticompetitive exclusive dealing even in the absence of scale economies and downstream competition.

Remark (Non-linear demand) The previous results rest on the assumption of a linear inverse demand function. We now relax this assumption to extend Section 3.2's analysis with a non-linear inverse demand function:

$$P(Q) = a - bQ^{\alpha}. \tag{6}$$

[17] If inputs A and B were substitutes, a reduction in input B's price would decrease demand for input A, and thus U_A would be required to lower A's price. In contrast, if inputs A and B are complements, a reduction in input B's price increases demand for input A.

We assume that $\alpha > 0$ so that the firms' second-order conditions are satisfied. We also assume that $a > ((1+\alpha)(c - c_E) + 2\alpha c)/\alpha$ so that U_{EB}'s monopoly price is higher than c. Comparing equations (2) and (6) reveals clearly that the linear demand case considered in the previous subsections is a special case in which $\alpha = 1$. The price elasticity of demand is given by

$$-\frac{dQ/Q}{dp/p} = \frac{p}{\alpha(a-p)}. \tag{7}$$

Equations (6) and (7) imply that as α increases (decreases), the demand curve becomes concave (convex) or inelastic (elastic). The following proposition shows that the likelihood of exclusion depends on the curve's shape.

Proposition 3. *Suppose that upstream suppliers adopt linear wholesale pricing. If U_A is the monopolistic supplier of input A, U_{IB} can deter socially efficient entry as a unique equilibrium outcome as long as the demand curve for the final product is not overly convex, $\alpha \geq \overline{\alpha} \simeq 0.40692$.*

This result has an important implication: exclusion is more likely to be observed when demand is inelastic. The curvature of the inverse demand curve influences the degree of demand expansion following socially efficient entry. When the inverse demand curve is concave ($\alpha > 1$), the demand-expansion effect of a new upstream entrant is weak; as a result, socially efficient entry does not lead to a large increase in D's profits, allowing U_{IB} to profitably compensate D. However, as the inverse demand curve becomes convex, the demand-expansion effect becomes significant; in other words, the double marginalization problem is more serious in the case of convex inverse demand. This leads to a large increase in D's profits, preventing U_{IB} from profitably compensating D.

3.3 Discussion

To probe how the monopoly power of a complementary input supplier influences the previous subsection's outcome, we briefly discuss the case in which a competitor also supplies complementary input A. We suppose that input A is produced by not only an incumbent supplier, U_{IA}, but also an inefficient supplier, U_{EA}. The marginal cost of U_{EA} is $d_A \in (c, a/2)$. We assume that U_{EA} enters the market for input A in Stage 2, that U_{IA} and U_{EA} are homogeneous Bertrand competitors, and that the fixed cost of entry is zero, enabling U_{EA} to enter the market for input A.[18] Note that the analyses in Sections 3.1 and 3.2 can be interpreted as the cases in which $d_A = c$ and $d_A \geq a/2$, respectively. The following proposition shows that the likelihood of exclusion depends on the difference in efficiency between the suppliers of complementary input A.[19]

Proposition 4. *Suppose that input A can be produced by U_{IA} and U_{EA}. U_{IB} can deter socially efficient entry as a unique equilibrium outcome if the efficiency difference between the suppliers of complementary input A is sufficiently large—that is, $d_A \geq \overline{d}_A$ where*

$$\overline{d}_A = a - c - \frac{a - 2c}{\sqrt{3}}.$$

Note that $c < \overline{d}_A < a/2$. The result here fills the gap between Propositions 1 and 2 and confirms the significance of the complementary input supplier being able to control its input price. When U_{EA}'s efficiency is high (that is, d_A is close to c), the existence of U_{EA} acts as a constraint on the pricing of U_{IA} and significantly dampens the monopoly power of U_{IA}. This implies that U_{IA} does not extract sufficient profits from D, regardless of whether U_{IB}'s exclusive offer is accepted. In this environment, engaging in exclusive dealing with U_{IB} significantly reduces D's profit through double marginalization.

In contrast, when U_{EA} is sufficiently inefficient (that is, $d_A \in ((a+c)/3, a/2)$), the existence of U_{EA} does not necessarily constrain the pricing of U_{IA}. On the one hand, if U_{IB}'s exclusive offer is accepted, the existence of U_{EA} never influences U_{IA}'s pricing decisions. On the other, if U_{IB}'s exclusive offer is rejected, the existence of U_{EA} does constrain U_{IA}'s pricing decisions. In this case, input A's price depends on U_{EA}'s efficiency, d_A. As noted in Section 3.2, the stronger the monopoly power of U_{IA}, the lower D's profitability if U_{IB}'s exclusive offer is rejected. Therefore, if U_{EA}'s efficiency is low enough that $d_A \geq \overline{d}_A$, then U_{IB} and D engage in

[18] If the entry cost is positive, U_{EA} does not enter the market for input A because it anticipates zero operating profits and cannot cover this fixed cost. It may be harder to justify this assumption. However, U_{EA} might enter even if it had to incur the fixed cost. For example, this might occur if there were upstream differentiation in the market for input A. Alternatively, if U_{EA} is already established and operating in other industries, it could supply input A without additional fixed costs.

[19] The result does not change even if we assume that both U_{IA} and U_{IB} independently and simultaneously make exclusive offers to D with fixed compensation $x_A (\geq 0)$ and $x_B (\geq 0)$, respectively.

anticompetitive exclusive dealing even in the presence of competition in the complementary input market.

Interpretation of these results yields an important policy implication for antitrust agencies: an increase in the cost efficiency of a dominant input supplier can facilitate anticompetitive exclusive dealing in complementary input markets. As the dominant input supplier becomes more efficient, industry output usually increases, which is socially efficient. However, if we consider the possibility of exclusive contracts in complementary input markets, an improvement in the efficiency of the dominant input supplier may trigger exclusion outcomes in complementary input markets, which is socially inefficient. Therefore, when considering real-world exclusive contracts, antitrust agencies should pay attention to not only the structure of the market in which the exclusive contracts are signed but also structural changes in related complementary input markets.

4 Non-linear wholesale pricing

In this section, we extend the analysis of the model in Section 3.2 to the case in which upstream suppliers use two-part tariffs in Stage 3. Two-part tariffs consist of a linear wholesale price and an upfront fixed fee; the two-part tariff offered by input supplier U_i when D accepts (rejects) the exclusive offer is denoted by (w_i^a, F_i^a) $((w_i^r, F_i^r))$, where $i \in \{A, IB, EB\}$. Under non-linear pricing, the double marginalization problem is avoidable, and the joint profit is maximized within the technological endowments available to firms. For notational convenience, we define $\Pi^*(z)$ as follows:

$$\Pi^*(z) \equiv \max_p (p - z - c)Q(p),$$

where $z \geq 0$ and $Q(p)$ is a general demand function. $\Pi^*(z)$ can be interpreted as the maximum joint profit when input B is supplied with marginal cost z. When entry does not occur (occurs), we have $z = c$ $(z = c_E)$. Hence, the difference between $\Pi^*(c_E)$ and $\Pi^*(c)$ depends on the difference between the efficiencies of U_{EB} and U_{IB}. To simplify the analysis, we assume that $\Pi^*(z)$ is continuous and strictly decreasing in z.

The rest of this section is organized as follows. In Section 4.1, we explore the case in which suppliers make take-it-or-leave-it offers. In Section 4.2, we explore the case in which the industry profit is allocated by bilateral Nash bargaining.

4.1 Take-it-or-leave-it offers

We first consider the case in which the exclusive offer is accepted in Stage 1. There are multiple equilibria in which U_A and U_{IB} respectively offer (c, F_A^a) and (c, F_{IB}^a) such that $F_A^a + F_{IB}^a = \Pi^*(c)$. The firms' equilibrium profits, excluding the fixed compensation x, are

$$0 \leq \pi_A^a \leq \Pi^*(c), \;\; 0 \leq \pi_{IB}^a \leq \Pi^*(c), \;\; \pi_D^a = 0,$$

where $\pi_A^a + \pi_{IB}^a = \Pi^*(c)$. Multiple equilibria consist of any $F_A^a \geq 0$ and $F_{IB}^a \geq 0$ such that $F_A^a + F_{IB}^a = \Pi^*(c)$.

We next consider the case in which the exclusive offer is rejected in Stage 1. In Stage 2, U_{EB} then enters the market for input B. In Stage 3, U_{IB} offers its best term $(c, 0)$. Anticipating this term, U_A and U_{EB} respectively offer (c, F_A^r) and (c_E, F_{EB}^r), which satisfy $\Pi^*(c_E) - F_{EB}^r - F_A^r \geq \Pi^*(c) - F_A^r$ if $F_A^r \leq \Pi^*(c)$ and $\Pi^*(c_E) - F_{EB}^r - F_A^r \geq 0$ if $F_A^r > \Pi^*(c)$. The inequalities that include F_{EB}^r indicate that D either prefers U_{EB}'s offer to that of U_{IB} or treats them equally. By arranging the condition, we conclude that (c, F_A^r) and (c_E, F_{EB}^r) satisfy the following: $0 \leq F_{EB}^r \leq \Pi^*(c_E) - \Pi^*(c)$ and $F_A^r + F_{EB}^r = \Pi^*(c_E)$. Firms' equilibrium profits are then given as follows:

$$\Pi^*(c) \leq \pi_A^r \leq \Pi^*(c_E), \;\; \pi_{IB}^r = \pi_D^r = 0, \;\; 0 \leq \pi_{EB}^r \leq \Pi^*(c_E) - \Pi^*(c),$$

where $\pi_A^r + \pi_{EB}^r = \Pi^*(c_E)$. Multiple equilibria consist of any $\Pi^*(c) \leq F_A^r \leq \Pi^*(c_E)$ and $0 \leq F_{EB}^r \leq \Pi^*(c_E) - \Pi^*(c)$ such that $F_A^r + F_{EB}^r = \Pi^*(c_E)$.

Finally, we check for the existence of exclusion. Because we have $\pi_{IB}^a + \pi_D^a - (\pi_{IB}^r + \pi_D^r) \geq 0$ with equality for $\pi_{IB}^a = 0$, inequality (5) always holds. Therefore, exclusion is always an equilibrium outcome.

Proposition 5. *Suppose that upstream suppliers adopt two-part tariffs and make take-it-or-leave-it offers. If U_A has market power, then U_{IB} can deter socially efficient entry as a unique equilibrium outcome.*

There are a few remarks that must be made regarding this subsection's analysis. First, as pointed out above, there exist multiple equilibria in Stage 3. Second, the profit allocation is not consistent with the linear wholesale pricing case. When complementary input suppliers adopt two-part tariffs, D earns zero operating profits regardless of its decision in Stage 1. Hence, the main intuition of the Chicago School argument, in which the downstream buyer enjoys a large surplus, cannot be applied. Third, if D is able to make take-it-or-leave-it offers, exclusion cannot be an equilibrium outcome because D can extract all of $\Pi^*(c_E)$ by offering $(c, 0)$ to U_A and $(c_E, 0)$ to U_{EB} in the case of U_{EB}'s entry. Hence, we must reconsider the analysis in a situation of more general bargaining power. In the next subsection, we provide a bilateral Nash Bargaining outcome with the following properties: a unique Stage 3 equilibrium outcome exists; D enjoys a larger surplus when entry occurs; and the possibility of exclusion can be explored with respect to the degree of bargaining power.

4.2 Bilateral Nash bargaining

Under our bargaining assumptions, when the exclusive offer is accepted in Stage 1, D and existing suppliers, U_A and U_{IB}, negotiate and make contract(s) for the two-part tariffs in Stage 3. We consider a form of simultaneous bilateral negotiation; that is, when negotiating with two suppliers, D simultaneously bargains with each of them separately.[20] Each bargaining session aims at contracting the two-part tariff D will transfer to the supplier. We assume that the outcome in Stage 3 is determined as follows. First, the outcome of each negotiation is given by the Nash bargaining solution, based on the belief that the outcome of bargaining with the other party is determined in the same way. Second, the net joint surplus is divided between D and the supplier in the proportion β to $1-\beta$, where $\beta \in (0, 1)$ represents D's bargaining power.

By contrast, when the exclusive offer is rejected in Stage 1, U_{EB} enters the market for input B in Stage 2. In Stage 3, D simultaneously negotiates separately with each of the suppliers, U_A and U_{EB}, and makes contract(s) for the two-part tariffs. If D and U_{EB} cannot reach an agreement, then D can bargain with U_{IB} given the contract (w_A^r, F_A^r).[21] The assumptions governing each bargaining procedure are the same as those applying in the case in which the exclusive

[20]For an application in the industrial organization literature in which industry profits are allocated according to bilateral Nash bargaining, see, for instance, Matsushima and Shinohara (2014) and references therein.

[21]It is not optimal for D to bargain first with U_{IB}.

offer is accepted.

We first consider the case in which the exclusive offer is accepted in Stage 1 and then U_{EB} does not enter in Stage 2. In Stage 3, D simultaneously negotiates with each of the suppliers, U_A and U_{IB}, separately and makes contract(s) for the two-part tariffs, (c, F_A^a) and (c, F_{IB}^a). Note that we do not discuss explicitly how the wholesale price is determined in each instance of bargaining because we can easily show that marginal cost pricing is achieved in both cases. For notational simplicity, we omit the discussion of how to determine the suppliers' wholesale prices. Given the contract (c, F_j^a), the bargaining problem between D and U_i is described by the payoff pairs $(\Pi^*(c) - F_i^a - F_j^a, F_i^a)$ and the disagreement point $(0, 0)$ ($i, j \in \{A, IB\}$ and $i \neq j$). The solution is given by:

$$F_i^a = \arg\max_{F_i} \ \beta \log[\Pi^*(c) - F_i - F_j^a] + (1 - \beta) \log F_i.$$

The firms' equilibrium profits, excluding the fixed compensation x, are

$$\pi_A^a = \pi_{IB}^a = \frac{(1 - \beta)\Pi^*(c)}{2 - \beta}, \ \ \pi_D^a = \frac{\beta\Pi^*(c)}{2 - \beta}. \tag{8}$$

We next consider the case in which the exclusive offer is rejected in Stage 1 and then U_{EB} enters the market for input B in Stage 2. In Stage 3, D simultaneously negotiates separately with each of the suppliers, U_A and U_{EB}, and makes contracts for the two-part tariffs, (c, F_A^r) and (c_E, F_{EB}^r). If D and U_{EB} cannot reach an agreement, then D can bargain with U_{IB} given the contract (c, F_A^r). We derive solutions by backward induction.

We first explore bargaining between D and U_{IB} off the equilibrium path. Given (c, F_A^r), the bargaining problem between D and U_{IB} off the equilibrium path is described by the payoff pairs $(\Pi^*(c) - F_A^r - F_{IB}^{r(o)}, F_{IB}^{r(o)})$ and the disagreement point $(0, 0)$. The solution is given by:

$$F_{IB}^{r(o)} = \arg\max_{F_{IB}} \ \beta \log[\Pi^*(c) - F_A^r - F_{IB}] + (1 - \beta) \log F_{IB}. \tag{9}$$

By solving this problem, D earns $\beta(\Pi^*(c) - F_A^r)$, which becomes D's outside option under bargaining with U_{EB}.[22]

[22]Under the negotiation characterized here, U_{IB} offers $(c, (1 - \beta)(\Pi^*(c) - F_A^r))$ and does not offer its best terms, $(c, 0)$. Hence, the competition between suppliers of input B is less intense than under homogeneous Bertrand competition. In Appendix B, we extend the analysis here to the case in which N entrants exist. We show that the negotiation (competition) among input B suppliers described here becomes more severe as the number of entrants increases and coincides with homogeneous Bertrand competition as a limiting case; even in such a case, however, the existence of U_A allows U_{IB} to deter socially efficient entry.

We now explore the bargaining between D and U_k on the equilibrium path, where $k \in \{A, EB\}$. Given (c_E, F^r_{EB}), the bargaining problem between D and U_A is described by the payoff pairs $(\Pi^*(c_E) - F^r_A - F^r_{EB}, F^r_A)$ and the disagreement point $(0, 0)$. The solution is given by:

$$F^r_A = \arg\max_{F_A} \beta \log[\Pi^*(c_E) - F_A - F^r_{EB}] + (1-\beta)\log F_A. \quad (10)$$

By contrast, the bargaining problem between D and U_{EB} given (c, F^r_A) is described by the payoff pairs $(\Pi^*(c_E) - F^r_A - F^r_{EB}, F^r_{EB})$ and the disagreement point $(\beta(\Pi^*(c) - F^r_A), 0)$. The solution is given by:

$$F^r_{EB} = \arg\max_{F_{EB}} \beta \log[\Pi^*(c_E) - F^r_A - F_{EB} - \beta(\Pi^*(c) - F^r_A)] + (1-\beta)\log F_{EB}. \quad (11)$$

By solving problems (10) and (11), the equilibrium firms' profits are given as follows:

$$\pi^r_A = \frac{(1-\beta)(\Pi^*(c_E) + (1-\beta)\Pi^*(c))}{\beta^2 + 3(1-\beta)}, \;\; \pi^r_{IB} = 0,$$

$$\pi^r_D = \frac{\beta(\Pi^*(c_E) + (1-\beta)\Pi^*(c))}{\beta^2 + 3(1-\beta)}, \;\; \pi^r_{EB} = \frac{(1-\beta)((2-\beta)\Pi^*(c_E) - \Pi^*(c))}{\beta^2 + 3(1-\beta)}.$$

Note that for all $\beta \in (0, 1)$, $\pi^r_D - \pi^a_D = \beta((2-\beta)\Pi^*(c_E) - \Pi^*(c))/(2-\beta)(\beta^2 + 3(1-\beta)) > 0$ and $\pi^r_A - \pi^a_A = (1-\beta)((2-\beta)\Pi^*(c_E) - \Pi^*(c))/(2-\beta)(\beta^2 + 3(1-\beta)) > 0$, which implies that socially efficient entry increases not only D's profits but also U_A's profits. Thus, the negotiation characterized here leads to a similar profit allocation in the case of linear wholesale pricing.

We finally consider the existence of exclusion. Condition (5) holds if and only if

$$\pi^a_{IB} + \pi^a_D - (\pi^r_{IB} + \pi^r_D) = \frac{(1 + (1-\beta)^2(2-\beta))\Pi^*(c) - \beta(2-\beta)\Pi^*(c_E)}{(2-\beta)(\beta^2 + 3(1-\beta))} \geq 0.$$

From this condition, we obtain the following proposition:

Proposition 6. *Suppose that upstream suppliers adopt two-part tariffs and that industry profits are allocated by bilateral Nash bargaining between D and upstream suppliers. If U_A has market power, U_{IB} can deter socially efficient entry as a unique equilibrium outcome if there is a sufficiently small difference in efficiency between U_{IB} and U_{EB} and D has limited bargaining power; that is,* $\Pi^*(c_E)/\Pi^*(c) \leq \phi(\beta)$, *where*

$$\phi(\beta) \equiv \frac{1 + (1-\beta)^2(2-\beta)}{\beta(2-\beta)}.$$

Note that for all $\beta \in (0, 1)$, we have $\phi(\beta) > 1$, $\phi'(\beta) < 0$, and $\phi''(\beta) > 0$ and that $\phi(\beta) \to \infty$ as $\beta \to 0$ and $\phi(\beta) \to 1$ as $\beta \to 1$.

Figure 3 summarizes the result of Proposition 6, showing that the possibility of exclusion is higher when D has less bargaining power. The intuition behind this result is as follows. When D has limited bargaining power, U_A extracts most of the increase in the firms' joint profits from U_{EB}'s entry whereas D enjoys a smaller increase in profits, which increases the possibility of exclusion. By contrast, when D has strong bargaining power, D obtains a larger increase in profits from U_{EB}'s entry whereas U_A enjoys a smaller increase in profits. Hence, there is less possibility of exclusion.

5 Concluding remarks

This study has explored the existence of anticompetitive exclusive dealing, extending the work of previous studies to consider the role of complementary inputs in the upstream market. It is essential that this interaction between complementary input suppliers not be neglected, as it is common for real-world downstream firms to transform multiple inputs into final products.

Our analysis showed that seemingly small differences in the model's setting can have crucial ramifications for the results. If the complementary input supplier has market power, then the inefficient incumbent supplier can deter socially efficient entry by using exclusive contracts even under the Chicago School argument's framework in which there is a single downstream buyer. On checking the robustness of our exclusion outcome, we showed that it does not depend on the assumption of linear demand or linear wholesale pricing; that is, our results remain valid when the final product demand curve is not too convex or when non-linear wholesale pricing is introduced. This study's analysis can thus be widely applied to real-world vertical relationships.

Our results also have novel and important implications for antitrust agencies: it is necessary to take into account the existence of complementary inputs when considering the possibility of anticompetitive exclusive dealing. If we discuss the anticompetitiveness of exclusive contracts while ignoring the existence of complementary input suppliers with market power, we might over-emphasize the results of the Chicago School argument. This study's results suggest that rational economic agents can easily engage in anticompetitive exclusive dealing in a market requiring multiple inputs to produce a downstream product for which demand is inelastic. Moreover, if the complementary input supplier considered here is interpreted as an industry-wide labor union, our results imply that the existence of unions plays a role in facilitating anticompetitive exclusive dealing.

Despite these contributions, there remain several outstanding issues requiring further research. The first involves extensions of our model to encompass other facets of the anticompetitive dealing literature. For example, we assume that the downstream firm is a monopolist. We predict that, as Simpson and Wickelgren (2007) and Abito and Wright (2008) discuss, adding downstream competition to our model would increase the likelihood of reaching an exclusion equilibrium. A second area for further analysis concerns the generality of our results. For example, the present study's analysis assumed Leontief production technology. While this might be appropriate for analyzing certain real-world situations, such as the Intel antitrust case, the result might also remain valid under more general production technologies. In addition, in Section 3.3 we assumed that the complementary input suppliers are homogeneous Bertrand competitors. If we were to add differentiation between the complementary input suppliers to our model, the likelihood of an exclusion equilibrium would increase. A real-world example of this is the case of Eastman Kodak v. Fuji, in which Kodak complained of exclusive contracts between Fuji and Japanese wholesalers that prevented Kodak from successfully entering Japan's photographic film market.[23] The Japanese camera market, which complements the film market, is characterized by dominant manufacturers such as Canon and Nikon. These manufacturers are somewhat differentiated and have market power because consumers face switching costs when considering changing cameras. Extensions and applications of our model can thus help researchers and policymakers address similar real-world issues.

[23] See, for example, Nagaoka and Goto (1997).

Appendix

A Proofs of All Results

Proof of Proposition 1

Before proceeding to the proof, we explain D's maximization problem. Given input prices w_A and w_B, the problem is given as

$$\max_{Q}\,(a - bQ - w_A - w_B)Q. \tag{12}$$

The level of output of the final product supplied by D and the demand for each input are given by

$$q_A = q_B = Q(w_A, w_B) \equiv \frac{a - w_A - w_B}{2b}. \tag{13}$$

When input A is competitively provided, we have $w_A^a = w_A^r = c$. We first explore the case in which the exclusive contract is accepted in Stage 1. The outcome in Stage 4 is given in (13). In Stage 3, U_{IB} sets the input price:

$$w_B^a = \arg\max_{w_B}(w_B - c)Q(c, w_B).$$

The equilibrium input prices are $w_B^a = a/2$ and $w_A^a = c$. From (13), the equilibrium production levels are $Q^a(c, a/2) = q_A^a = q_B^a = (a - 2c)/6b$. The firms' equilibrium profits, excluding the fixed compensation x, are

$$\pi_A^a = 0,\;\; \pi_{IB}^a = \frac{(a-2c)^2}{8b},\;\; \Pi_D^a = \frac{(a-2c)^2}{16b}. \tag{14}$$

We next explore the case in which the exclusive offer is rejected in Stage 1. Then, U_{EB} enters the B market in Stage 2. In Stage 3, competition in the B market reduces input B's price to U_{IB}'s marginal cost; i.e., $w_B^r = c$. From (13), the equilibrium production levels are $Q^r(c, c) = q_A^r = q_B^r = (a - 2c)/2b$. The equilibrium profits are

$$\pi_A^r = \pi_{IB}^r = 0,\;\; \pi_D^r = \frac{(a-2c)^2}{4b}. \tag{15}$$

Finally, we check the existence of an exclusion equilibrium. From (14) and (15), we have

$$\pi_{IB}^a + \pi_D^a - (\pi_{IB}^r + \pi_D^r) = -\frac{(a-2c)^2}{16b} < 0,$$

which implies that condition (5) never holds.

Q.E.D.

Proof of Lemma 1

Suppose first that the exclusive offer is accepted in Stage 1. The maximization problem faced by D in Stage 4 is given by (12). The output of the final product supplied by D and the demand for each input are given by (13). The maximization problem of input i supplier in Stage 3 is given as

$$\max_{w_i \geq c}(w_i - c)Q(w_i, w_j), \tag{16}$$

where $i, j \in \{A, B\}$ and $i \neq j$. The first-order conditions lead to the equilibrium input prices:

$$w_A^a = w_B^a = \frac{a + c}{3}. \tag{17}$$

From (13), the equilibrium production levels are $Q^a = q_A^a = q_B^a = Q((a + c)/3, (a + c)/3) = (a - 2c)/6b$. The firms' equilibrium profits, excluding the fixed compensation x, are

$$\pi_A^a = \pi_{IB}^a = \frac{(a - 2c)^2}{18b}, \quad \pi_D^a = \frac{(a - 2c)^2}{36b}. \tag{18}$$

Suppose next that the exclusive offer is rejected in Stage 1. In this case, U_{EB} enters the B market in Stage 2. The maximization problem faced by D in Stage 4 is given by (12). The output of the final product supplied by D and the demand for each input are given by (13). The competition in the B market in Stage 3 leads to $w_B^r = c$. By contrast, the maximization problem of U_A in Stage 3 is given by (16). The equilibrium price of input A is

$$w_A^r = \frac{a}{2}. \tag{19}$$

From (13), the equilibrium production levels are $Q^r = q_A^r = q_B^r = (a - 2c)/4b$. The equilibrium profits of firms are

$$\pi_A^r = \frac{(a - 2c)^2}{8b}, \quad \pi_{IB}^r = 0, \quad \pi_D^r = \frac{(a - 2c)^2}{16b}. \tag{20}$$

From (17) and (19), we have the following relation:

$$w_A^a - w_A^r = -\frac{a - 2c}{6} < 0.$$

Therefore, entry into the B market increases input A's price.

Q.E.D.

Proof of Proposition 2

From (18) and (20), we have

$$\pi_{IB}^{a} + \pi_{D}^{a} - (\pi_{IB}^{r} + \pi_{D}^{r}) = \frac{(a-2c)^2}{48b} > 0,$$

which implies that condition (5) always holds.

Q.E.D.

Proof of Proposition 3

We first consider the case in which the exclusive offer is accepted in Stage 1. The firms' equilibrium profits, excluding the fixed compensation x, are

$$\pi_{A}^{a} = \pi_{IB}^{a} = \frac{\alpha}{((1+\alpha)b)^{\frac{1}{\alpha}}}\left(\frac{a-2c}{1+2\alpha}\right)^{\frac{1+\alpha}{\alpha}}, \quad \pi_{D}^{a} = \frac{\alpha}{b^{\frac{1}{\alpha}}}\left(\frac{\alpha(a-2c)}{(1+\alpha)(1+2\alpha)}\right)^{\frac{1+\alpha}{\alpha}}.$$

We next consider the case in which the exclusive offer is rejected in Stage 1. The equilibrium profits of the firms are given by

$$\pi_{A}^{r} = \frac{\alpha}{((1+\alpha)b)^{\frac{1}{\alpha}}}\left(\frac{a-2c}{1+\alpha}\right)^{\frac{1+\alpha}{\alpha}}, \quad \pi_{IB}^{r} = 0, \quad \pi_{D}^{r} = \frac{\alpha}{b^{\frac{1}{\alpha}}}\left(\frac{a-2c}{(1+\alpha)^2}\right)^{\frac{1+\alpha}{\alpha}}.$$

Finally, we consider the existence of exclusion. By using above results, we have

$$\pi_{IB}^{a} + \pi_{D}^{a} - (\pi_{IB}^{r} + \pi_{D}^{r}) = \frac{\alpha(a-2c)^{\frac{1+\alpha}{\alpha}}}{b^{\frac{1}{\alpha}}} \frac{(1+\alpha)^{\frac{2(1+\alpha)}{\alpha}}(2+\alpha) - ((1+\alpha)(1+2\alpha))^{\frac{1+\alpha}{\alpha}}}{(1+\alpha)^{\frac{3(1+\alpha)}{\alpha}}(1+2\alpha)^{\frac{1+\alpha}{\alpha}}} \geq 0,$$

if and only if $\alpha \geq \overline{\alpha}$. Therefore, condition (5) holds if and only if $\overline{\alpha} < \alpha$.

Q.E.D.

Proof of Proposition 4

We first consider the case in which U_{IB}'s exclusive offer is accepted in Stage 1. The existence of U_{EA} acts as a constraint on the pricing of U_{IA} although U_{IA} is the supplier of input A on the equilibrium path. U_{IB} monopolistically sets input B's price. The maximization problem faced by D in Stage 4 is given by (12). The output of the final product supplied by D and the demand for each input are as in (13). The maximization problems of U_{IA} and U_{IB} in Stage 3 are given by

$$\max_{w_A} \, (w_A - c)\frac{a - w_A - w_B}{2b}, \quad s.t. \;\; w_A \le d_A,$$
$$\max_{w_B} \, (w_B - c)\frac{a - w_A - w_B}{2b}.$$

These maximization problems lead to

$$w_A^a = \begin{cases} d_A & \text{if } c < d_A < \dfrac{a+c}{3}, \\ \dfrac{a+c}{3} & \text{if } d_A \ge \dfrac{a+c}{3}, \end{cases} \qquad w_B^a = \begin{cases} \dfrac{a+c-d_A}{2} & \text{if } c < d_A < \dfrac{a+c}{3}, \\ \dfrac{a+c}{3} & \text{if } d_A \ge \dfrac{a+c}{3}. \end{cases}$$

The equilibrium production levels are

$$q_A^a = q_B^a = Q^a = \begin{cases} \dfrac{a - d_A - c}{4b}, & \text{if } c < d_A < \dfrac{a+c}{3}, \\ \dfrac{a-2c}{6b}, & \text{if } d_A \ge \dfrac{a+c}{3}. \end{cases}$$

The equilibrium profits, excluding the fixed compensation x, are given by

$$\pi_{IA}^a \;\; = \;\; \begin{cases} \dfrac{(d_A - c)(a - d_A - c)}{4b} & \text{if } c < d_A < \dfrac{a+c}{3}, \\ \dfrac{(a-2c)^2}{18b}, & \text{if } d_A \ge \dfrac{a+c}{3}, \end{cases}$$
$$\pi_{IB}^a \;\; = \;\; \begin{cases} \dfrac{(a - d_A - c)^2}{8b} & \text{if } c < d_A < \dfrac{a+c}{3}, \\ \dfrac{(a-2c)^2}{18b} & \text{if } d_A \ge \dfrac{a+c}{3}. \end{cases}$$
$$\pi_{D}^a \;\; = \;\; \begin{cases} \dfrac{(a - d_A - c)^2}{16b} & \text{if } c < d_A < \dfrac{a+c}{3}, \\ \dfrac{(a-2c)^2}{36b} & \text{if } d_A \ge \dfrac{a+c}{3}, \end{cases}$$

Second, we consider the case in which U_{IB}'s exclusive offer is rejected in Stage 1. As in the first case, the existence of U_{EA} acts as a constraint on the pricing of U_{IA}. The equilibrium supplier of input B is U_{EB}, and its price is $w_B^r = c$. The maximization problem faced by D in Stage 4 is given by (12). The output of the final product supplied by D and the demand for each input are given by (13). The maximization problem of U_{IA} in Stage 3 is given as

$$\max_{w_A} \, (w_A - c)\frac{a - w_A - c}{2b}, \quad s.t. \;\; w_A \le d_A.$$

This maximization problem leads to

$$w_A^r = \begin{cases} d_A & \text{if } c < d_A < \dfrac{a}{2}, \\ \dfrac{a}{2} & \text{if } d_A \geq \dfrac{a}{2}. \end{cases}$$

The equilibrium production levels are

$$q_A^r = q_B^r = Q^r = \begin{cases} \dfrac{a - d_A - c}{2b}, & \text{if } c < d_A < \dfrac{a}{2} \\ \dfrac{a - 2c}{4b}, & \text{if } d_A \geq \dfrac{a}{2}. \end{cases}$$

The equilibrium profits are

$$\begin{aligned} \pi_{IA}^r &= \begin{cases} \dfrac{(d_A - c)(a - d_A - c)}{2b}, & \text{if } c < d_A < \dfrac{a}{2} \\ \dfrac{(a - 2c)^2}{8b}, & \text{if } d_A \geq \dfrac{a}{2}, \end{cases} \\ \pi_{IB}^r &= 0. \\ \pi_D^r &= \begin{cases} \dfrac{(a - d_A - c)^2}{4b}, & \text{if } c < d_A < \dfrac{a}{2} \\ \dfrac{(a - 2c)^2}{16b}, & \text{if } d_A \geq \dfrac{a}{2}, \end{cases} \end{aligned}$$

From now on, we explore the existence of exclusion. Applying the above results, we have

$$\begin{aligned} & \pi_{IB}^a + \pi_D^a - (\pi_{IB}^r + \pi_D^r) \\ = & \begin{cases} -\dfrac{(a - d_A - c)^2}{16b} & \text{if } c < d_A < \dfrac{a + c}{3}, \\ \dfrac{\sqrt{3}\left\{d_A - ((a - c) - (a - 2c)/\sqrt{3})\right\}\left\{(a - 2c) + \sqrt{3}(a - d_A - c)\right\}}{12b} & \text{if } \dfrac{a + c}{3} \leq d_A < \dfrac{a}{2}, \\ \dfrac{(a - 2c)^2}{48b} & \text{if } d_A \geq \dfrac{a}{2}. \end{cases} \end{aligned}$$

It is easy to see that condition (5) holds if and only if $d_A \geq \overline{d}_A$.

Q.E.D.

B Nash bargaining under N entrants

This appendix extends Section 4.2's analysis to the case of N entrants. Entrants here are denoted by $U_{EB(n)}$, where $n \in \{1, 2, .., N\}$.[24] For simplicity, we assume that $U_{EB(n)}$ has the same marginal cost c_E and that, as in Section 3.3, the fixed cost of entry is zero, enabling N entrants to enter the market for input B. By extending the analysis of Section 4.2, we consider the following competition among input B suppliers. When the exclusive offer is rejected in Stage 1, N entrants enter the market for input B in Stage 2. In Stage 3, D simultaneously negotiates with each of equilibrium suppliers, U_A and $U_{EB(N)}$, separately and makes contract(s) for the two-part tariffs. If D and $U_{EB(N)}$ cannot reach an agreement, then D can bargain with $U_{EB(N-1)}$ given the contract (c, F_A^r). If D and $U_{EB(N-1)}$ cannot reach an agreement, then D can bargain with $U_{EB(N-2)}$ given (c, F_A^r). In this way, bargaining off the equilibrium path continues. After N bargaining failures, D can bargain with U_{IB}, which is the final bargaining partner. To understand the importance of a complementary input supplier, we first discuss a benchmark case in which input A is not required for producing the final product in B.1. In B.2, we then explore the case in which input A is required to produce the final product.

B.1 Benchmark: When input A is not required for final-good production

In this subsection, we assume that input A is not required to produce the final product and that D uses production technology $Q = q_B$ under which one unit of the final product is made with one unit of input B. As in Section 4.2, we define $\Pi^{**}(z)$ as follows:

$$\Pi^{**}(z) \equiv \max_p (p - z)Q(p).$$

$\Pi^{**}(z)$ can be interpreted as the maximum joint profit when input B is supplied with marginal cost z. When entry does not occur (occurs), we have $z = c$ ($z = c_E$). As in Section 4.2, we assume that $\Pi^{**}(z)$ is continuous and strictly decreasing in z.

We first consider the case in which the exclusive offer is accepted in Stage 1. In Stage 3, D negotiates with U_{IB} and makes a contract for the two-part tariffs, (c, F_{IB}^a). The bargain-

[24] Multiple entrants are introduced by Kitamura (2010). By extending the model of Abito and Wright (2008), Kitamura (2010) explores the case of multiple entrants and shows that the possibility of exclusion decreases in such an environment.

ing problem between D and U_{IB} is described by the payoff pairs $(\Pi^{**}(c) - F^a_{IB}, F^a_{IB})$ and the disagreement point $(0, 0)$. The solution is given by:

$$F^a_{IB} = \arg\max_{F_{IB}} \beta \log[\Pi^{**}(c) - F_{IB}] + (1-\beta)\log F_{IB}.$$

The firms' equilibrium profits, excluding the fixed compensation x, are

$$\pi^a_{IB} = (1-\beta)\Pi^{**}(c), \;\; \pi^a_D = \beta\Pi^{**}(c).$$

We next consider the case in which the exclusive offer is rejected in Stage 1. In Stage 2, N entrants enter the market for input B. In Stage 3, D negotiates with $U_{EB(N)}$ and makes a contract for the two-part tariffs $(c_E, F^r_{EB(N)})$. As in Section 4.2, we derive solutions by backward induction. The bargaining problem between D and U_{IB} off the equilibrium path is described by the payoff pairs $(\Pi^{**}(c) - F^{r(o)}_{IB}, F^{r(o)}_{IB})$ and the disagreement point $(0, 0)$. The solution is given by:

$$F^{r(o)}_{IB} = \arg\max_{F_{IB}} \beta \log[\Pi^{**}(c) - F_{IB}] + (1-\beta)\log F_{IB}.$$

Solving this problem, D earns $\beta\Pi^{**}(c)$, which becomes D's outside option under bargaining with $U_{EB(1)}$. The bargaining problem between D and $U_{EB(1)}$ off the equilibrium path is described by the payoff pairs $(\Pi^{**}(c_E) - F^{r(o)}_{EB(1)}, F^{r(o)}_{EB(1)})$ and the disagreement point $(\beta\Pi^{**}(c), 0)$. The solution is given by

$$F^{r(o)}_{EB(1)} = \arg\max_{F_{EB(1)}} \beta \log[\Pi^{**}(c_E) - F_{EB(1)} - \beta\Pi^{**}(c)] + (1-\beta)\log F_{EB(1)}.$$

Solving this problem, D earns $\Pi^{**}(c_E) - (1-\beta)(\Pi^{**}(c_E) - \beta\Pi^{**}(c))$, which becomes D's outside option under bargaining with $U_{EB(2)}$. In this way, we can obtain firms' equilibrium profits for the case of N entrants:

$$\pi^r_{IB} = 0, \;\; \pi^r_D = \Pi^{**}(c_E) - (1-\beta)^N(\Pi^{**}(c_E) - \beta\Pi^{**}(c)), \;\; \pi^r_{EB(N)} = (1-\beta)^N(\Pi^{**}(c_E) - \beta\Pi^{**}(c)).$$

Note that π^r_D is strictly increasing in N whereas $\pi^r_{EB(N)}$ is strictly decreasing in N; this implies that the competition characterized here is like Cournot competition in that it becomes more severe as the number of entrants increases. In addition, as $N \to \infty$, we have $\pi^r_D \to \Pi^{**}(c_E) > \pi^a_D$ and $\pi^r_{EB(N)} \to 0$; namely, the competition characterized here coincides with homogeneous Bertrand competition in which each entrant offers $(c_E, 0)$ as a limiting case.

We finally consider the existence of exclusion. Condition (5) holds if and only if

$$\pi^a_{IB} + \pi^a_D - (\pi^r_{IB} + \pi^r_D) = -(\Pi^{**}(c_E) - \Pi^{**}(c)) + (1-\beta)^N(\Pi^{**}(c_E) - \beta\Pi^{**}(c)) \geq 0.$$

From this condition, we obtain the following proposition:

Proposition B.1. *Suppose that upstream suppliers adopt two-part tariffs and industry profits are allocated by bilateral Nash bargaining between D and upstream suppliers. If D's production technology is $Q = q_B$, U_{IB} cannot deter socially efficient entry by using exclusive contracts for an infinite number of entrants. More concretely, exclusion is possible if the difference in efficiency between U_{IB} and U_{EB} is sufficiently small and D has limited bargaining power; that is, $\Pi^*(c_E)/\Pi^*(c) \leq \eta(\beta, N)$ where*

$$\eta(\beta, N) = \frac{1-\beta(1-\beta)^N}{1-(1-\beta)^N}.$$

Note that for all $N \in \mathbb{N}$ and $\beta \in (0,1)$, $\eta(\beta, N) > 1$, $\eta(\beta, N) < \eta(\beta, N-1)$, and $\partial\eta(\beta, N)/\partial\beta < 0$ and that $\eta(\beta, N) \to 1$ as $N \to \infty$ or $\beta \to 1$.

The results here imply that the analysis in Section 4.2 is imperfect at clarifying that the existence of U_A plays an essential role in deterring socially efficient entry because the competition among the finite number of input B suppliers characterized here is weaker than homogeneous Bertrand competition. To see this, consider the case of $N = 1$, which corresponds with the framework of Section 4.2. In this case, condition (5) holds if and only if $\Pi^{**}(c_E)/\Pi^{**}(c) \leq \eta(\beta, 1) = (1-\beta(1-\beta))/\beta > 1$ for all $\beta \in (0,1)$. Thus, for $N = 1$, the exclusion equilibrium exists even in the absence of U_A if the efficiency difference between input B suppliers is sufficiently small and D has limited bargaining power. Therefore, we need to explore whether the result in Section 4.2 holds for the infinite number of entrants.[25]

[25]Multiple entrants cannot be neglected in the model of Fumagalli, Motta, and Rønde (2012). If we introduce multiple entrants or bilateral Nash bargaining under an infinite number of entrants into the model of Fumagalli, Motta, and Rønde (2012), socially inefficient exclusion does not occur. The main reason why exclusion is possible under their model is that the competition between the incumbent supplier and the entrant supplier diminishes the investment level of the incumbent supplier, which allows the efficient entrant supplier to set a higher input price. When multiple entrants exist, entrants cannot set a higher input price; this allows the downstream buyer to earn higher profits. Appendix B.2 shows that the existence of a complementary input supplier with strong market power leads to socially inefficient exclusion even for an infinite number of entrants, thereby clarifying the essential role of the complementary input supplier with market power.

B.2 When input A is required for final-good production

We now assume that input A, supplied by U_A, is required to produce the final product and that D uses production technology $Q = \min\{q_A, q_B\}$. We first consider the case in which the exclusive offer is accepted in Stage 1. Because the bargaining problem when the exclusive offer is accepted coincides with the one in Section 4.2, equilibrium firms' profits are given by (8).

We next consider the case in which the exclusive offer is rejected in Stage 1. In Stage 2, N entrants enter the market for input B. In Stage 3, D simultaneously negotiates with each of the suppliers, U_A and $U_{EB(N)}$, and makes contracts for the two-part tariffs, (c, F^r_A) and $(c_E, F^r_{EB(N)})$. We derive solutions by backward induction. We first explore the bargaining problem between D and input B suppliers off the equilibrium path. From the discussion in Section 4.2, the bargaining problem between D and U_{IB} and that between D and $U_{EB(1)}$ off the equilibrium path given (c, F^r_A) are given by (9) and (11), respectively. Solving these problems yields the result that D earns $\Pi^*(c_E) - F^r_A - (1-\beta)(\Pi^*(c_E) - \beta\Pi^*(c) - (1-\beta)F^r_A)$, which becomes D's outside option under bargaining with $U_{EB(2)}$. In this way, the bargaining between D and $U_{EB(N-1)}$ off the equilibrium path given (c, F^r_A) enables D to earn $\Pi^*(c_E) - F^r_A - F^{r(O)}_{EB(N-1)}$, where $F^{r(O)}_{EB(N-1)} = (1-\beta)^{N-1}(\Pi^*(c_E) - \beta\Pi^*(c) - (1-\beta)F^r_A)$. We now explore the bargaining between D and U_k on the equilibrium path, where $k \in \{A, EB(N)\}$. The bargaining problem between D and $U_{EB(N)}$ given (c, F^r_A) is described by the payoff pairs $(\Pi^*(c_E) - F^r_A - F^r_{EB(N)}, F^r_{EB(N)})$ and the disagreement point $(\Pi^*(c_E) - F^r_A - F^{r(O)}_{EB(N-1)}, 0)$. The solution is given by:

$$F^r_{EB(N)} = \arg\max_{F_{EB(N)}} \beta \log[\Pi^*(c_E) - F^r_A - F_{EB(N)} - (\Pi^*(c_E) - F^r_A - F^{r(o)}_{EB(N-1)})] + (1-\beta)\log F_{EB(N)}. \quad (21)$$

By contrast, the bargaining problem between D and U_A given $(c_E, F^r_{EB(N)})$ is described by the payoff pairs $(\Pi^*(c_E) - F^r_A - F^r_{EB(N)}, F^r_A)$ and the disagreement point $(0, 0)$. The solution is given by:

$$F^r_A = \arg\max_{F_A} \beta \log[\Pi^*(c_E) - F_A - F^r_{EB(N)}] + (1-\beta)\log F_A. \quad (22)$$

By solving problems (21) and (22), we can obtain equilibrium firms' profits for the case of N entrants:

$$\pi^r_A = \frac{(1-\beta)(\Pi^*(c_E) - (1-\beta)^N(\Pi^*(c_E) - \beta\Pi^*(c)))}{1-(1-\beta)^{2+N}}, \;\; \pi^r_{IB} = 0,$$

$$\pi^r_D = \frac{\beta(\Pi^*(c_E) - (1-\beta)^N(\Pi^*(c_E) - \beta\Pi^*(c)))}{1-(1-\beta)^{2+N}}, \quad \pi^r_{EB} = \frac{\beta(1-\beta)^N((2-\beta)\Pi^*(c_E) - \Pi^*(c))}{1-(1-\beta)^{2+N}}.$$

Note that as $N \to \infty$, $\pi^r_{EB(N)} \to 0$, $\pi^r_D \to \beta\Pi^*(c_E) > \pi^a_D$, and $\pi^r_A \to (1-\beta)\Pi^*(c_E) > \pi^a_A$; as in the linear pricing case, socially efficient entry increases not only D's profits but also U_A's profits.[26]

We finally consider the existence of exclusion. Condition (5) holds if and only if

$$\pi^a_{IB} + \pi^a_D - (\pi^r_{IB} + \pi^r_D) = \frac{(1-(1-\beta)^N(\beta+(1-\beta)^3))\Pi^*(c) - \beta(2-\beta)(1-(1-\beta)^N)\Pi^*(c_E)}{(2-\beta)(1-(1-\beta)^{2+N})} \geq 0.$$

From this condition, we obtain the following proposition:

Proposition B.2. *Suppose that upstream suppliers adopt two-part tariffs and industry profits are allocated by bilateral Nash bargaining between D and upstream suppliers. If input A, supplied by U_A, is required to produce the final product, U_{IB} can deter socially efficient entry as a unique equilibrium outcome even for an infinite number of entrants. More concretely, exclusion is possible given a sufficiently small difference in efficiency between U_{IB} and $U_{EB(n)}$ and limited bargaining power for D; that is,* $\Pi^*(c_E)/\Pi^*(c) \leq \psi(\beta, N)$ *where*

$$\psi(\beta, N) = \frac{1-(1-\beta)^N(\beta+(1-\beta)^3)}{\beta(2-\beta)(1-(1-\beta)^N)}.$$

Note that for all $N \in \mathbb{N}$, $\psi(\beta, N) > 1$ and $\psi(\beta, N) < \psi(\beta, N-1)$ and that $\psi(\beta, 1) = \phi(\beta)$ and $\psi(\beta, N) \to 1/\beta(2-\beta)$ as $N \to \infty$.

The result here implies that the exclusion result under linear wholesale pricing is valid even when we apply the general demand function and a profit allocation rule based on bilateral Nash bargaining with an infinite number of entrants. B.1's model showed that in the absence of U_A, D is the unique player obtaining all benefits in the case of the entry of an infinite number of entrants, which makes exclusion impossible. Hence, the Chicago School argument can apply. However, B.2 showed that the existence of U_A prevents D from being the only player to obtain all of these benefits even for an infinite number of entrants, which makes exclusion possible. Therefore, we can conclude that the existence of U_A plays an essential role in deterring socially efficient entry.

[26] Both inequalities hold if and only if $(2-\beta)\Pi^*(c_E) - \Pi^*(c) > 0$. It is easy to see that this condition holds for all $\beta \in (0, 1)$.

C Vertical product differentiation

In this appendix, we extend Section 3.2's analysis to the case in which input B suppliers produce vertically differentiated inputs. The basic model structure here follows Argenton (2010), who explores a model of anticompetitive exclusive contracts when upstream suppliers' products are vertically differentiated. Although Argenton (2010) explores the case of two downstream firms with no complementary input supplier, we explore the case of a single downstream firm with a complementary input supplier.

The quality of the final product for which input B is supplied by U_i is denoted by μ_i, where $i \in \{IB, EB\}$. Following Argenton (2010), we assume that U_{EB} produces a higher quality input, $\mu_{EB} > \mu_{IB}$, and that for simplicity all firms' marginal costs are zero; that is, $c_{IB} = c_{EB} = c_A = 0$. Consumer preferences follow the standard in the literature on vertical product differentiation. There is a unit mass of consumers, indexed by θ, which is uniformly distributed on the interval $[0, 1]$. Consumers decide whether to purchase one unit of one of the final products. To purchase one unit of the final product with quality μ_i, a consumer of type θ pays p_i and enjoys consumer surplus $\theta\mu_i - p_i$. The consumer is assumed to purchase a given final product if and only if the consumer surplus is nonnegative; i.e., $\max\{\theta\mu_{IB} - p_{IB}, \theta\mu_{EB} - p_{EB}\} \geq 0$. Moreover, the consumer purchases the final product with quality μ_i if $\theta\mu_i - p_i \geq \theta\mu_j - p_j$, where $i, j \in \{IB, EB\}$ and $i \neq j$.

Demand for each final product depends on the results of Stage 1. First, when the exclusive offer is accepted in Stage 1, only U_{IB} supplies input B. Thus, demand for the final product with quality μ_{IB} becomes

$$Q_{IB}(p_{IB}) = 1 - \frac{p_{IB}}{\mu_{IB}}.$$

Second, when the exclusive offer is rejected in Stage 1, U_{IB} and U_{EB} supply input B and compete in input prices. In this case, demand for the final product with quality μ_{EB} becomes

$$Q_{EB}(p_{IB}, p_{EB}) = 1 - \frac{p_{EB} - p_{IB}}{\mu_{EB} - \mu_{IB}}.$$

By contrast, demand for the final product with quality μ_{IB} becomes

$$Q_{IB}(p_{IB}, p_{EB}) = \frac{p_{EB} - p_{IB}}{\mu_{EB} - \mu_{IB}} - \frac{p_{IB}}{\mu_{IB}}.$$

The rest of this appendix is organized as follows. To understand the importance of a complementary input supplier, we first discuss a benchmark case in which input A is not required for producing the final product in C.1. We then explore the case in which input A is required for producing the final product in C.2.

Before we discuss the suppliers' pricing, we derive the demand for the products given the determined input prices. First, we consider a case in which D produces the low-quality product that includes the input of U_{IB}. The maximization problem faced by D is given by

$$\max_{p_{IB}} (p_{IB} - w_A - w_{IB})Q_{IB}(p_{IB}).$$

The price of the final product and demand for input B are given by

$$p_{IB}(w_A, w_{IB}) = \frac{\mu_{IB} + w_A + w_{IB}}{2}, \quad Q_{IB}(w_A, w_{IB}) = \frac{\mu_{IB} - w_A - w_{IB}}{2\mu_{IB}}. \tag{23}$$

Second, we consider a case in which D produces both low- and high-quality final products that include, respectively, the inputs of U_{IB} and U_{EB}. The maximization problem faced by D is given by

$$\max_{p_{IB}, p_{EB}} (p_{IB} - w_A - w_{IB})Q_{IB}(p_{IB}, p_{EB}) + (p_{EB} - w_A - w_{EB})Q_{EB}(p_{IB}, p_{EB}).$$

The price of each final product and demand for each input are given by

$$p_{IB}(w_A, w_{IB}) = \frac{\mu_{IB} + w_A + w_{IB}}{2}, \quad p_{EB}(w_A, w_{EB}) = \frac{\mu_{EB} + w_A + w_{EB}}{2},$$

$$Q_{IB}(w_A, w_{IB}, w_{EB}) = \frac{\mu_{IB} w_{EB} - \mu_{EB} w_{IB} - (\mu_{EB} - \mu_{IB}) w_A}{2\mu_{IB}(\mu_{EB} - \mu_{IB})}. \tag{24}$$

$$Q_{EB}(w_{IB}, w_{EB}) = \frac{\mu_{EB} - \mu_{IB} - w_{EB} + w_{IB}}{2(\mu_{EB} - \mu_{IB})}, \tag{25}$$

C.1 Benchmark: When input A is not required for final-good production

In this subsection, we assume that input A is not required for producing the final product and that D uses production technology $Q = q_B$, which corresponds to a case in which D can purchase input A for free; $w_A^a = w_A^r = 0$.

We first consider the case in which the exclusive offer is accepted in Stage 1. Using the outcome in (23), we solve the maximization problem of U_{IB} and can then obtain the equilibrium input price and firms' profits, excluding the fixed compensation x:

$$w_{IB}^{a} = \frac{\mu_{IB}}{2}, \ \ \pi_{IB}^{a} = \frac{\mu_{IB}}{8}, \ \ \pi_{D}^{a} = \frac{\mu_{IB}}{16}.$$

We next consider the case in which the exclusive offer is rejected in Stage 1. Using the outcome in (24) and (25), we solve the maximization problems of U_{IB} and U_{EB} and then obtain the equilibrium input prices and firm profits:

$$\begin{aligned} w_{IB}^{r} &= \frac{\mu_{IB}(\mu_{EB}-\mu_{IB})}{4\mu_{EB}-\mu_{IB}}, \ \ w_{EB}^{r} = \frac{2\mu_{EB}(\mu_{EB}-\mu_{IB})}{4\mu_{EB}-\mu_{IB}}, \\ \pi_{IB}^{r} &= \frac{\mu_{EB}\mu_{IB}(\mu_{EB}-\mu_{IB})}{2(4\mu_{EB}-\mu_{IB})^2}, \ \ \pi_{D}^{r} = \frac{\mu_{EB}^2(4\mu_{EB}+5\mu_{IB})}{4(4\mu_{EB}-\mu_{IB})^2}, \ \ \pi_{EB}^{r} = \frac{2\mu_{EB}^2(\mu_{EB}-\mu_{IB})}{(4\mu_{EB}-\mu_{IB})^2}. \end{aligned}$$

Finally, we consider the existence of exclusion. By using the above results, we have

$$\pi_{IB}^{a} + \pi_{D}^{a} - (\pi_{IB}^{r} + \pi_{D}^{r}) = -\frac{4\mu_{EB}(\mu_{EB}-\mu_{IB}) + 3\mu_{IB}^2}{16(4\mu_{EB}-\mu_{IB})} < 0,$$

which implies that condition (5) never holds. Hence, we obtain the following proposition:

Proposition C.1. *Suppose that the products of the suppliers of input B are vertically differentiated and that upstream suppliers adopt linear wholesale pricing. If D's production technology is $Q = q_B$, U_{IB} cannot deter socially efficient entry by using exclusive contracts for any degree of product differentiation.*

C.2 When input A is required for final-good production

We now assume that input A, supplied by U_A, is required to produce the final product and D uses production technology $Q = \min\{q_A, q_B\}$.

We first consider the case in which the exclusive offer is accepted in Stage 1. Using the outcome in (23), we solve the maximization problems of U_A and U_{IB} and then obtain the equilibrium input prices and firm profits, excluding the fixed compensation x:

$$w_{A}^{a} = w_{IB}^{a} = \frac{\mu_{IB}}{3}, \ \ \pi_{A}^{a} = \pi_{IB}^{a} = \frac{\mu_{IB}}{18}, \ \ \pi_{D}^{a} = \frac{\mu_{IB}}{36}.$$

We next consider the case in which the exclusive offer is rejected in Stage 1. Using the outcome in (24) and (25), we solve the maximization problems of U_A, U_{IB}, and U_{EB} and then have the equilibrium input prices and firm profits:

$$w_A^r = \frac{\mu_{IB}}{2}, \;\; w_{IB}^r = 0, \;\; w_{EB}^r = \frac{\mu_{EB} - \mu_{IB}}{2},$$
$$\pi_A^r = \frac{\mu_{IB}}{8}, \;\; \pi_{IB}^r = 0, \;\; \pi_D^r = \frac{\mu_{EB}}{16}, \;\; \pi_{EB}^r = \frac{\mu_{EB} - \mu_{IB}}{8}.$$

We finally consider the existence of exclusion. Condition (5) holds if and only if

$$\pi_{IB}^a + \pi_D^a - (\pi_{IB}^r + \pi_D^r) = \frac{4\mu_{IB} - 3\mu_{EB}}{48} \geq 0.$$

From this condition, we obtain the following proposition:

Proposition C.2. *Suppose that the products of the suppliers of input B are vertically differentiated and that upstream suppliers adopt linear wholesale pricing. If D's production technology is* $Q = \min\{q_A, q_B\}$ *and* U_A *is the monopolistic supplier of input A,* U_{IB} *can deter socially efficient entry as a unique equilibrium outcome for a sufficiently small degree of product differentiation; that is,* $\mu_{EB}/\mu_{IB} \leq 4/3$.

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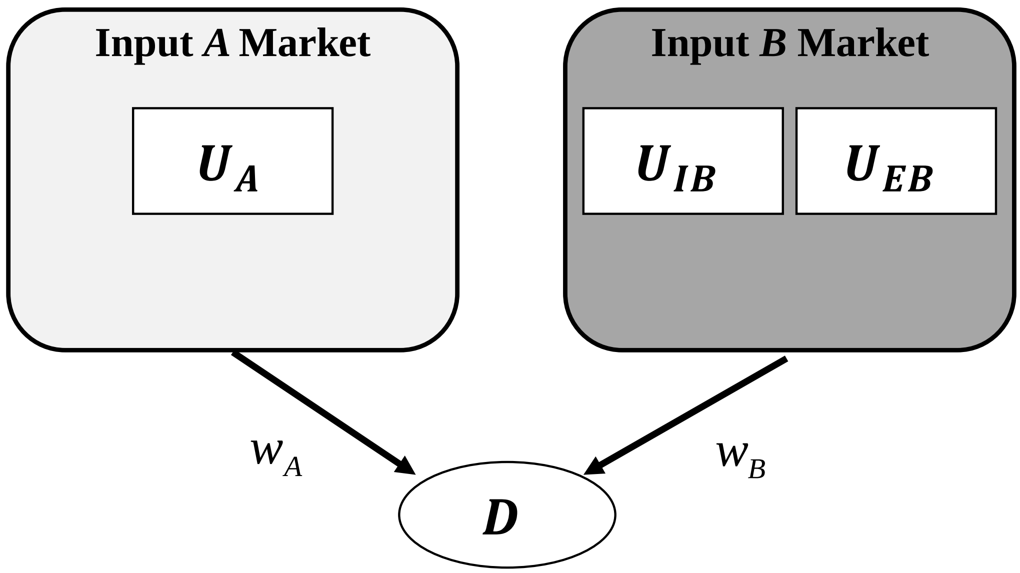

Figure 1: Market Structures

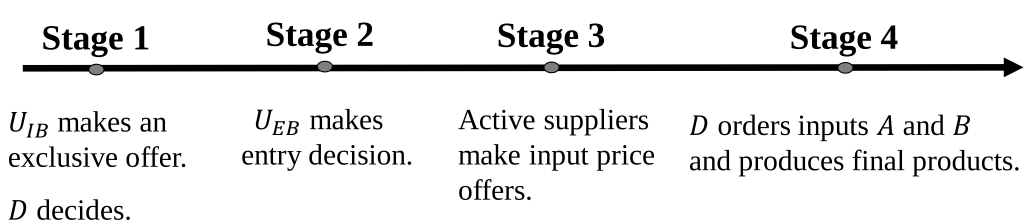

Figure 2: Timeline

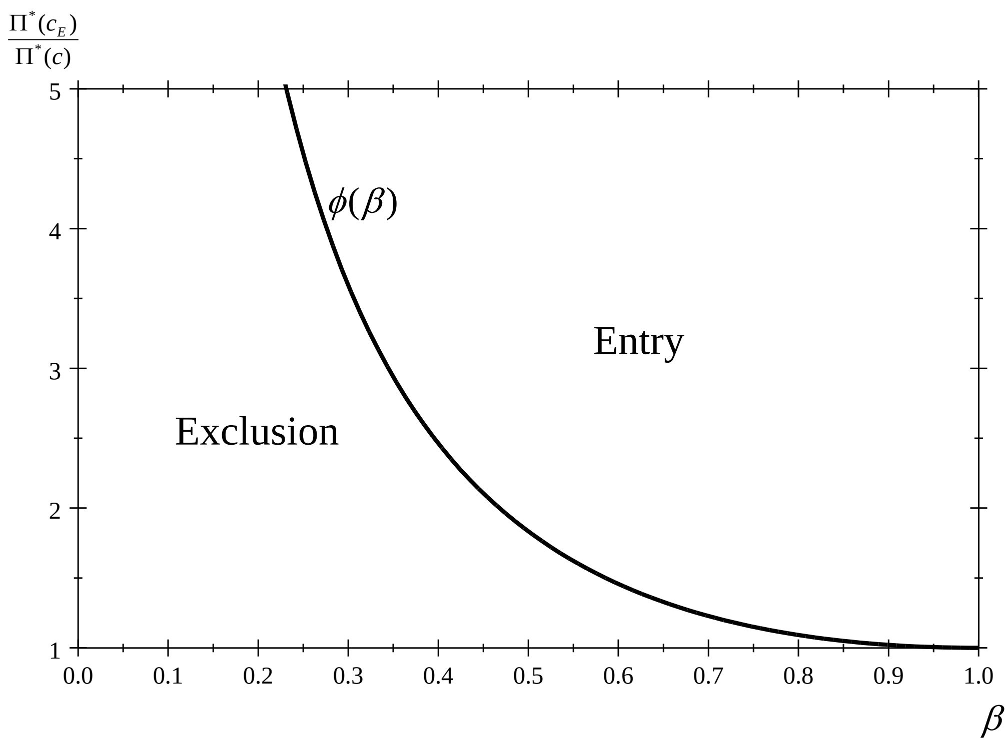

Figure 3: Results of Proposition 6