How Does Downstream Firms' Efficiency Affect Exclusive Supply Agreements?*

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Abstract

This paper constructs a model for examining anticompetitive exclusive supply contracts that prevent an upstream supplier from selling input to a new downstream firm. With regard to the technology to transform the input produced by the supplier, as an entrant becomes increasingly efficient, its input demand decreases, and thus, the supplier earns smaller profits when socially efficient entry is allowed. Hence, the inefficient incumbent can deter socially efficient entry via exclusive supply contracts, even in the framework of the Chicago School argument where a single seller, a single buyer, and a single entrant exist.

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1 Introduction

Exclusive contracts have long been controversial, because once signed, these deter efficient entrants and reduce welfare. Therefore, such contracts seem to be anticompetitive—a view opposed by the Chicago School. For instance, by constructing a model of an exclusive contract between an upstream incumbent and a downstream buyer, Posner (1976) and Bork (1978) argue that the rational buyer does not sign such a contract to deter a more efficient entrant. The Chicago School argument remains highly influential.[1]

In rebuttal of the Chicago School argument, post-Chicago economists indicate specific circumstances under which anticompetitive, exclusive dealings occur.[2] Their studies, by extending the single-buyer model of the Chicago School argument to a multiple-buyer model, introduce scale economies wherein the entrant needs a certain number of buyers to cover its fixed costs (Rasmusen, Ramseyer, and Wiley (1991) and Segal and Whinston (2000a)) and the competition between buyers (Simpson and Wickelgren (2007) and Abito and Wright (2008)).

A feature common to these studies is that the upstream incumbent makes exclusive offers to downstream firms. However, in a real business situation involving input suppliers and final good producers, downstream firms might offer exclusive supply contracts to upstream firms. For example, the Federal Trade Commission (FTC) in the U.S. stopped a large drug maker from enforcing 10-year exclusive supply agreements for an essential ingredient.[3] Hence, this paper aims to ascertain the existence of anticompetitive exclusive supply contracts that prevent an upstream supplier from selling inputs to a new downstream entrant.

This paper presents a model of anticompetitive exclusive supply contracts by inverting the vertical relationship in the Chicago School argument. The model comprises one upstream supplier and one downstream incumbent. A new downstream firm, which needs an input produced by the upstream supplier, appears as an entrant. The incumbent then offers an ex-

[1] For the impact of the Chicago School argument on antitrust policies, see Motta (2004) and Whinston (2006).

[2] In an early contribution, Aghion and Bolton (1987) propose a model in which exclusion does not always occur. However, when it does, it is anticompetitive. See also a study by Bernheim and Whinston (1998), which explores the market circumstances under which an exclusive contract can exclude rival incumbents.

[3] *FTC v. Mylan Laboratories, Inc., Cambrex Corporation, Profarmaco S.R.I., and Gyma Laboratories of America, Inc.*, No.X990015-1. For more details, visit the FTC website: http://www.ftc.gov/os/caselist/x990015ddc.shtm.

clusive supply contract to the upstream supplier, as in the standard models of anticompetitive exclusive dealing. If the contract is achieved, then the new entrant cannot enter the market.

Under the standard model setting above, we consider two types of efficiency measures to evaluate the efficiency of the incumbent and entrant downstream firms. The first measure is that the entrant is more efficient than the incumbent in terms of its per unit production cost for several inputs, such as labor, which are not produced by the upstream supplier. As this measure is commonly used in existing literature, we use it as a benchmark. The second measure is that the entrant is more efficient than the incumbent in terms of a transformational technology of an input produced by the upstream supplier; that is, the entrant demands a smaller quantity of inputs from the supplier to produce one unit of final product.

Thus, under both measures, in terms of per unit production cost, the entrant is more efficient than the incumbent. Note that the model in this paper differs not only in relation to the market structure where exclusion occurs, but also in the efficiency measures of the incumbent and entrant. Previous studies on anticompetitive exclusive contracts assume that the per unit production cost of an entrant is lower than that of an upstream incumbent. However, these studies do not differentiate between the kinds of efficiency advantages possessed by the entrant.

This paper shows that, under exclusive supply contracts, a seemingly small difference in the two efficiency measures is actually crucial. We first show that, when the entrant is efficient in terms of per unit cost of other inputs, exclusion never arises as in the framework of the Chicago School argument where a single upstream incumbent offers an exclusive contract to a single downstream buyer to deter a single upstream entrant. In contrast, when the entrant is efficient in terms of the transformational technology of an input produced by the upstream supplier, exclusion becomes possible if the entrant is sufficiently efficient.

To understand our results, consider the impact of socially efficient entry from the viewpoint of the upstream supplier. A socially efficient entry generates downstream competition and increases the final product output. This increases the demand for the input produced by the upstream supplier and consequently, its profit. The demand expansion effect of socially efficient entry makes anticompetitive exclusive dealings difficult.

If we measure the downstream firms' efficiency by per unit cost of other inputs, then the efficient entrant's entry is necessarily beneficial for the upstream supplier. As the entrant becomes efficient, it increases the production level of the final product, and thus, it demands a larger quantity of the input produced by the upstream supplier; that is, an improvement of the entrant's efficiency facilitates the demand expansion effect of socially efficient entry. This allows the upstream supplier to earn larger profits when the socially efficient entry occurs, which makes anticompetitive exclusive dealings more difficult and therefore, exclusion of an efficient entrant impossible.

However, if we measure the downstream firms' efficiency by the transformational technology of input produced by the upstream supplier, then the efficient entrant's entry is not necessary beneficial for the upstream supplier. As the entrant becomes increasingly efficient, it demands a smaller quantity of the input produced by the upstream supplier. In addition, an improvement in the entrant's efficiency diminishes the market share of the downstream incumbent, which demands a larger quantity of the input produced by the upstream supplier. Therefore, as the entrant becomes efficient, its entry does not lead to a large increase in the demand for the input produced by the upstream supplier; that is, the upstream supplier does not welcome the highly efficient entrant. This allows the upstream supplier to engage in anticompetitive exclusive dealings to deter socially efficient entry into the downstream market.

This paper is related to the literature on anticompetitive exclusive dealings to deter upstream entrants.[4] Fumagalli and Motta (2006) propose an extension of the model framed by Rasmusen, Ramseyer, and Wiley (1991) and Segal and Whinston (2000a) where buyers are competing firms.[5] They show that intense downstream competition reduces the possibility of exclusion. However, Simpson and Wickelgren (2007) and Abito and Wright (2008) point

[4]Certain studies examine procompetitive exclusive dealings. Marvel (1982), Besanko and Perry (1993), Segal and Whinston (2000b), de Meza and Selvaggi (2007), and de Fontenay, Gans, and Groves (2010) investigate the role of exclusive dealing in encouraging non-contractible investments. Chen and Sappington (2011) study the impact of exclusive contracts on industry R&D and welfare. Fumagalli, Motta, and Rønde (2012) examine the interaction between procompetitive and anticompetitive effects. They show that the investment promotion effect of exclusive dealing may facilitate anticompetitive exclusive dealing. In addition, Argenton and Willems (2012) study the trade-off between the positive effect (risk sharing) and the negative effect (exclusion) of exclusive contracts.

[5]Fumagalli and Motta (2008) also show that exclusion with scale economies arises because of coordination failure among buyers even when the incumbent does not have a first-mover advantage in making exclusive offers. Doganoglu and Wright (2010) explore exclusion in the presence of network externalities, an example of scale economies.

out that this result depends on the assumption that buyers are undifferentiated Bertrand competitors who need to incur epsilon participation fees to stay active. They show that if buyers are differentiated Bertrand competitors, then intense downstream competition enhances exclusion even in the presence of epsilon participation fees.[6]

Wright (2008) and Argenton (2010) explore extended models of exclusion with downstream competition where the incumbent and a potential entrant produce horizontally and vertically, respectively, a differentiated product. Both studies show that the resulting exclusive dealing is anticompetitive.[7] Furthermore, economists have recently analyzed anticompetitive exclusive dealings from an experimental perspective (Boone, Müller, and Suetens, 2009, Landeo and Spier, 2009, 2012, and Smith, 2011).

The remainder of this paper is organized as follows. In Section 2, we construct the model. In Section 3, we analyze the case where downstream firms compete in price. In Section 4, we analyze the case where downstream firms compete in quantity. In Section 5, we provide discussions and in Section 6, concluding remarks. In Appendix A and Appendix B, we present the proofs of results under price competition and quantity competition, respectively.

2 Model

This section develops the basic environment of the model. We first explain the basic characteristics of players in the model in Section 2.1. Then, the timing of the game is introduced in Section 2.2. Finally, we introduce the design of exclusive supply contracts in Section 2.3. For convenience, we consider the relationships between input suppliers and final good producers, although this model is suitable for a much more general application. For example, the model can be applied to the relationships between final good producers and retailers.

[6] See also Wright's (2009) study, which corrects the result of Fumagalli and Motta (2006) in the case of two-part tariffs.

[7] Kitamura (2010, 2011) also explores the extended model—first, in the presence of multiple entrants, and next, in the presence of financial constraints. Johnson (2012) extends the models in the presence of adverse selection. Kitamura, Sato, and Arai (forthcoming) explore the model when the incumbent can establish a direct retailer. These studies show that the resulting exclusive dealings are anticompetitive. In contrast, Gratz and Reisinger (2011) show that exclusive contracts can possibly have procompetitive effects, if downstream firms compete imperfectly and contract breaches are possible.

2.1 Upstream and downstream markets

The downstream market is composed of an incumbent D_I and an entrant D_E. Each of them produces a unit of final product using inputs A and B. Input A is exclusively produced by an upstream supplier U_A. For this supplier, the marginal cost is $c_A \geq 0$ and w_A is the wholesale price of input A offered. Input B is supplied by competitive sectors such as competitive labor at price $c_B \geq 0$ to the downstream firms.

Downstream firms differ in the production technology.[8] Incumbent D_I produces a unit of final product using one unit of input A and one unit of input B. The transformation technology is denoted by

$$Q_I = \min\{q_{A|I}, q_{B|I}\}, \tag{1}$$

where $q_{j|I}$ is the amount of input $j \in \{A, B\}$ for D_I. The per unit production cost of downstream incumbent D_I, w_I, is denoted by

$$w_I = w_A + c_B. \tag{2}$$

In contrast, entrant D_E produces a unit of final product using k units of input A and m units of input B, where k and m are positive constants. The transformation technology is denoted by

$$Q_E = \min\left\{\frac{q_{A|E}}{k}, \frac{q_{B|E}}{m}\right\}, \tag{3}$$

where $q_{j|E}$ is the amount of input $j \in \{A, B\}$ for D_E. The per unit production cost of entrant D_E, w_E, is denoted by

$$w_E = kw_A + mc_B. \tag{4}$$

Equation (4) implies that entrant D_E becomes efficient (that is, the per unit cost of entrant D_E decreases) as k or m decreases. We assume that $k \leq 1$ and $m \leq 1$. On comparing (2) with (4), it is easy to see that under both the efficiency measures for downstream firms, entrant D_E is more efficient than incumbent D_I in terms of per unit production cost.[9]

The efficiency measure of downstream firms in this paper differs from that in previous studies on anticompetitive exclusive dealing. Previous studies do not focus on the difference

[8]The basic model structure in the production technology follows that of Matsushima and Mizuno (2012).

[9]For convenient comparison between efficiency measures, we assume that downstream firms use multiple inputs with Leontief production technology, although our main results do not require multiple inputs.

in the transformational technology of input A, because they explore the existence of entry deterrence in the upstream market. In measuring the upstream firms' efficiency, it is natural and robust to assume that the price of input supplied by competitive sectors differs for the upstream firms and that the upstream entrant D_E has the smaller per unit production cost because it has an advantage, namely, the transformational technology of the competitively supplied input. In contrast, this paper focuses on the existence of entry deterrence in the downstream market. In line with studies on entry deterrence in the upstream market, we assume that downstream firms differ in the cost of labor. However, in our model, the difference in transformational technology of inputs produced by upstream suppliers is also an important efficiency measure for downstream firms.

2.2 Timing of the game

The timing of the game is as follows (see also Figure 1). The model consists of four stages. In Stage 1, the downstream incumbent I offers an exclusive supply contract to the upstream supplier U_A. This contract involves some fixed compensation $x \geq 0$. Supplier U_A decides whether to accept this offer. In Stage 2, entrant D_E decides whether to enter the downstream market. We assume that the fixed cost of entry is sufficiently small such that if entrant D_E is active, it could earn positive profits. In Stage 3, supplier U_A offers a linear wholesale price of input A, w_A, to the active downstream firm(s). There are two cases (see Figure 2). If supplier U_A accepts the exclusive supply offer in Stage 1, then it offers the input price w_A^a only to the downstream incumbent. In contrast, if supplier U_A rejects the exclusive supply offer in Stage 1, then it offers the input price w_A^r to all active downstream firms. We assume that supplier U_A cannot offer different wholesale prices to downstream firms. (In Section 5, we discuss the case where such price discrimination is possible.) In Stage 4, active downstream firm(s) order the input and compete in the final market. If entry arises in Stage 2, then incumbent D_I and entrant D_E compete. In Section 3, we analyze the case where downstream firms are undifferentiated Bertrand competitors. In Section 4, we analyze the case where downstream firms compete in quantity. The incumbent's profit in the case when supplier U_A accepts (rejects) the exclusive offer is denoted by Π_I^a (Π_I^r), and supplier U_A's profit in the case when it accepts (rejects) the exclusive offer is denoted by π_A^a (π_A^r).

2.3 The design of exclusive supply contracts

Given the equilibrium outcomes in the subgame following Stage 1, we derive the essential conditions for an exclusive supply contract. For the existence of an exclusion equilibrium, the equilibrium transfer x^* needs to satisfy the following two conditions.

First, it has to satisfy individual rationality for the downstream incumbent D_I; that is, D_I must earn higher operating profits under exclusive dealing, such that

$$\Pi_I^a - x \geq \Pi_I^r. \tag{5}$$

Second, it has to satisfy individual rationality for the upstream supplier U_A; that is, the compensation amount x must induce U_A to accept the exclusive supply offer, because

$$x + \pi_A^a \geq \pi_A^r. \tag{6}$$

From the above conditions, it is easy to see that an exclusion equilibrium exists if and only if inequalities (5) and (6) hold simultaneously. This is equivalent to the following condition:

$$\Pi_I^a + \pi_A^a \geq \Pi_I^r + \pi_A^r. \tag{7}$$

Condition (7) implies that for the existence of anticompetitive exclusive supply contracts, we need to examine whether exclusive supply agreements increase the joint profits of incumbent D_I and supplier U_A.

3 Price Competition

This section considers, in two subsections, the existence of anticompetitive exclusive dealings to deter the socially efficient entry of D_E when downstream firms are undifferentiated Bertrand competitors. We assume that the general demand function $Q(p)$ is continuous, $Q'(p) < 0$, and $Q''(p) \leq 0$ at all price p such that $Q(p) > 0$, and that there exists a $\overline{p} < \infty$ such that $Q(p) = 0$ for all $p \geq \overline{p}$. We also assume that $\overline{p} > c_A + c_B$. We assume that demand from the downstream firm D_i, where $i \in \{I, E\}$, depends not only on its price but also on that of the downstream firm D_{-i}. The quantity that consumers demand from D_i is $Q(p_i)$ when $p_i < p_{-i}$ and 0 when $p_i > p_{-i}$. When $p_i = p_{-i}$, the downstream firm with the lower per unit production cost supplies the entire quantity $Q(p_i)$. For notational convenience, we define $p^*(z)$ and $\pi^*(z)$ as follows:

$$p^*(z) \equiv \arg\max_{p}(p - z)Q(p), \tag{8}$$

$$\pi^*(z) \equiv (p^*(z) - z)Q(p^*(z)), \tag{9}$$

where $z \geq 0$.

To understand more easily the role of inefficiency in the transformational technology of input A, in Section 3.1, we introduce a benchmark analysis where downstream firms have the same transformational technology of input A but differ in costs of input B. In Section 3.2, we then analyze the case where downstream firms differ in the transformational technology of input A but incur identical costs on input B.

3.1 Benchmark: when downstream firms have the same transformational technology of input produced by the upstream supplier

Assume that downstream firms have the same transformational technology of input A but differ in costs of input B; that is, $k = 1$ and $m < 1$ (see Figure 3). We measure the entrant's efficiency by m.

We first consider the case where supplier U_A accepts the exclusive offer in Stage 1. In this case, it can supply only to incumbent D_I. Given the input price w_A^a, incumbent D_I optimally chooses $p_I^a(w_A^a) = p^*(w_A^a + c_B)$ in Stage 4. By anticipating this pricing, supplier U_A sets the input price for incumbent D_I to maximize its profit in Stage 3.

$$w_A^a = \arg\max_{w_A}(w_A - c_A)Q(p^*(w_A + c_B)). \tag{10}$$

Because we have $w_A^a > c_A$ in the equilibrium, the equilibrium price level $p^*(w_A^a + c_B)$ does not maximize the joint profits of D_I and U_A; that is, the double marginalization problem occurs.

$$\begin{aligned} \Pi_I^a + \pi_A^a &= (p^*(w_A^a + c_B) - (c_A + c_B))Q(p^*(w_A^a + c_B)) \\ &< \pi^*(c_A + c_B). \end{aligned} \tag{11}$$

Figure 4 summarizes the equilibrium outcome under linear demand when supplier U_A accepts the exclusive offer in Stage 1. The entry deterrence allows incumbent D_I to earn higher operating profits. However, incumbent D_I and supplier U_A cannot maximize their joint profits, because of the double marginalization problem.

However, when supplier U_A rejects the exclusive supply offer in Stage 1, entrant D_E enters the downstream market in Stage 2. In Stage 4, given the input price w_A^r, the downstream firms compete in price. The undifferentiated Bertrand competition leads to the following two types of equilibrium outcomes:

Case (i) D_I offers $p_{I|m<1}^{r(i)} = w_A^r + c_B$ and D_E offers $p_{E|m<1}^{r(i)} = w_A^r + c_B$, if $p^*(w_A^r + mc_B) \geq w_A^r + c_B$.

Case (ii) D_I offers $p_{I|m<1}^{r(ii)} = w_A^r + c_B$ and D_E offers $p_{E|m<1}^{r(ii)} = p^*(w_A^r + mc_B)$, if $p^*(w_A^r + mc_B) < w_A^r + c_B$.

The price of D_E is binding in Case (i), although it is not in Case (ii). Note that D_I's profit is always zero; that is, $\Pi_{I|m<1}^r = 0$. For expositional simplicity, we only consider Case (i) here and consider Case (ii) in Appendix B.

By anticipating this pricing in Stage 4, supplier U_A optimally chooses the input price $w_{A|m<1}^{r(i)} \equiv \arg\max_{w_A}(w_A - c_A)Q(w_A + c_B)$ in Stage 3. By defining $\tilde{w}_A \equiv w_A + c_B$, we can rewrite the profit maximization problem for supplier U_A as follows:

$$\begin{aligned} \pi_{A|m<1}^{r(i)} &= \max_{\tilde{w}_A}(\tilde{w}_A - (c_A + c_B))Q(\tilde{w}_A) \\ &= \pi^*(c_A + c_B) \\ &> \Pi_I^a + \pi_A^a. \end{aligned} \tag{12}$$

Equation (12) implies that D_E's entry allows supplier U_A to earn profits equivalent to the maximized value of the joint profits of supplier U_A and incumbent D_I. Therefore, exclusion is impossible. The following proposition shows that this result also holds in Case (ii), and thus, exclusion never occurs as long as we assume that downstream firms have the same transformational technology of input A.

Proposition 1. *Suppose that downstream firms have the same transformational technology of input A ($k = 1$ and $m < 1$) and that they are undifferentiated Bertrand competitors. Then, the downstream incumbent D_I cannot deter socially efficient entry by using an exclusive supply contract.*

Figure 5 summarizes the equilibrium outcome when supplier U_A rejects the exclusive supply offer in Stage 1. D_E's entry generates downstream competition, which mitigates double marginalization and increases the final product output. This expands the demand for input A and raises supplier U_A's profit. Therefore, D_E's entry allows U_A to earn large profits as given by $\pi^r_{A|m<1}$. By comparing Figures 4 and 5, it is easy to see that even by using its operating profits under an exclusive dealing, incumbent D_I cannot compensate supplier U_A for these large profits.

In addition, when downstream firms have the same transformational technology of input A, an improvement of D_E's efficiency is more likely to lead to the lower equilibrium price ($p^{r(ii)}_{E|m<1} < w^{r(ii)}_{A|m<1} + c_B$), which raises the demand of input A, and thus, allows U_A to earn larger profits. This makes it more difficult for incumbent D_I to compensate supplier U_A.

Note that the model setting in this subsection corresponds to that of the Chicago School argument by inverting the vertical relationship in their model. The Chicago School introduces a model where a single upstream incumbent offers an exclusive contract to a single downstream buyer to deter an efficient upstream entrant, and concludes that rational economic agents do not engage in anticompetitive exclusive dealings. The result in Proposition 1 implies that the Chicago School argument can be applied regardless of whether the incumbent is an upstream firm or a downstream firm as long as we assume that entrant D_E is more efficient in terms of the cost of input B.

3.2 When downstream firms differ in the transformational technology of input produced by the upstream supplier

We now assume that downstream firms differ in the transformational technology of input A; that is, $k < 1$ (See Figure 6). For analytical simplicity, we assume that $m = 1$. There are two interpretations of this assumption. First, in the relationships between an input supplier and final good producers, entrant D_E has the efficient technology that allows it to reduce the use of input A or to reduce defective products. Second, in the relationships between a final good producer and retailers, the entrant retailer D_E is better at supply-chain management than the incumbent, owing to which it need not hold excess inventories of final products produced by final good producer U_A.

Note that the equilibrium outcomes under exclusive dealing do not depend on the efficiency of entrant D_E. Thus, the only difference from Section 3.1 appears in the subgame after supplier U_A rejects the exclusive supply offer in Stage 1. Just as in Section 3.1, the incumbent earns zero profits in this subgame; that is, $\Pi^r_{I|k<1} = 0$ for all $0 < k < 1$. In addition, as in Section 3.1, downstream competition leads to two types of equilibria in Stage 4. The undifferentiated Bertrand competition leads to the following outcomes:

Case (i) D_I offers $p^{r(i)}_{I|k<1} = w^r_A + c_B$ and D_E offers $p^{r(i)}_{E|k<1} = w^r_A + c_B$, if $p^*(kw^r_A + c_B) \geq w^r_A + c_B$.

Case (ii) D_I offers $p^{r(ii)}_{I|k<1} = w^r_A + c_B$ and D_E offers $p^{r(ii)}_{E|k<1} = p^*(kw^r_A + c_B)$, if $p^*(kw^r_A + c_B) < w^r_A + c_B$.

By anticipating this pricing in Stage 4, supplier U_A optimally chooses its input price in Stage 3. Note that for each case, we have a unique interior solution $(w^{r(i)}_{A|k<1}, w^{r(ii)}_{A|k<1}) \in (c_A, \infty)^2$, because we assume that $Q'(p) < 0$ and $Q''(p) \leq 0$.

We characterize the properties of each interior solution on the domain $[c_A, \infty)$. First, in Case (i), supplier U_A faces its input demand

$$q^{r(i)}_{E|k<1} = kQ(w^r_A + c_B). \tag{13}$$

Given this input demand, the upstream supplier U_A optimally chooses input price $w^{r(i)}_{A|k<1} \equiv \arg\max_{w^r_A} k(w^r_A - c_A)Q(w^r_A + c_B)$ in Stage 3. By using the definition $\tilde{w}^r_A \equiv w^r_A + c_B$, we can rewrite the profit maximization problem for supplier U_A as follows:

$$\begin{aligned} \pi^{r(i)}_{A|k<1} &= \max_{\tilde{w}^r_A} k(\tilde{w}^r_A - (c_A + c_B))Q(\tilde{w}^r_A) \\ &= k\pi^*(c_A + c_B). \end{aligned} \tag{14}$$

From equations (12) and (14), we identify the following properties.

Lemma 1. *Under the interior solution $w^{r(i)}_{A|k<1} \in (c_A, \infty)$, $\pi^{r(i)}_{A|k<1}$ have the following properties:*

1. *$\pi^{r(i)}_{A|k<1}$ strictly increasing in k but decreasing in c_A.*

2. *As $k \to 1$, $\pi^{r(i)}_{A|k<1} \to \pi^*(c_A + c_B) > \Pi^a_I + \pi^a_A$.*

3. *As $k \to 0$, $\pi^{r(i)}_{A|k<1} \to 0$.*

Second, in Case (ii), supplier U_A faces its input demand $q^{r(ii)}_{E|k<1} = kQ(p^*(kw^r_A + c_B))$. Given this input demand, supplier U_A chooses the input price to maximize its profit in Stage 3;

$$\begin{aligned} \pi^{r(ii)}_{A|k<1} &= \max_{w^r_A}(w^r_A - c_A)kQ(p^*(kw^r_A + c_B)) \\ &= \max_{\hat{w}^r_A}(\hat{w}^r_A - c_B)Q(p^*(\hat{w}^r_A)) - kc_A Q(p^*(\hat{w}^r_A)). \end{aligned} \tag{15}$$

where $\hat{w}^r_A \equiv kw^r_A + c_B$. From equations (10) and (15), we identify the following properties.

Lemma 2. *Under the interior solution $w^{r(ii)}_{A|k<1} \in (c_A, \infty)$, $\pi^{r(ii)}_{A|k<1}$ have the following properties:*

1. *$\pi^{r(ii)}_{A|k<1}$ is strictly decreasing in k and c_A.*
2. *As $k \to 1$, $\pi^{r(ii)}_{A|k<1} \to \pi^a_A$.*
3. *For any $c_A \geq 0$, as $k \to 0$, $\pi^{r(ii)}_{A|k<1} \to \pi^a_A|_{c_A=0}$.*
4. *For $c_A = 0$, $\pi^{r(ii)}_{A|k<1} = \pi^a_A|_{c_A=0}$,*

where $\pi^a_A|_{c_A=0}$ is U_A's profit level under the standard double marginalization problem when $c_A = 0$ (see (10)).

We now characterize these two equilibria on two domains, namely, $[c_A, w^r_A(k)]$ and $[w^r_A(k), \infty)$, where $w^r_A(k)$ is the input price satisfying $p^*(kw^r_A(k) + c_B) = w^r_A(k) + c_B$ for each k and is the threshold value at which the mode in Stage 4 changes from Case (i) to Case (ii). The following lemma shows that at least one interior solution exists for all $0 < k < 1$.

Lemma 3. *At least one of the following holds, namely, $w^{r(i)}_{A|k<1} \in (c_A, w^r_A(k))$ or $w^{r(ii)}_{A|k<1} \in (w^r_A(k), \infty)$.*

Because we have $\pi^{r(i)}_{A|k<1} = \pi^{r(ii)}_{A|k<1}$ for $w^{r(i)}_{A|k<1} = w^{r(ii)}_{A|k<1} = w^r_A(k)$, we can conclude that one of the interior solutions mentioned above becomes the optimal solution in equilibrium. Therefore, exclusion is possible regardless of equilibrium types if we have

$$\Pi^a_I + \pi^a_A > \max\{\pi^{r(i)}_{A|k<1}, \pi^{r(ii)}_{A|k<1}\}. \tag{16}$$

The following lemma characterizes the properties of $\max\{\pi^{r(i)}_{A|k<1}, \pi^{r(ii)}_{A|k<1}\}$.

Lemma 4. $\max\{\pi^{r(i)}_{A|k<1}, \pi^{r(ii)}_{A|k<1}\}$ *has the following properties.*

1. *It is strictly decreasing in* c_A.

2. *Its functional form is V-shaped with respect to k; that is, there exists a minimized value* $k' \in (0,1)$*. More precisely, we have*

$$\max\{\pi^{r(i)}_{A|k<1}, \pi^{r(ii)}_{A|k<1}\} = \begin{cases} \pi^{r(ii)}_{A|k<1} & \text{if } 0 < k \leq k', \\ \pi^{r(i)}_{A|k<1} & \text{if } k' < k < 1. \end{cases} \tag{17}$$

Figure 7 summarizes the property of $\max\{\pi^{r(i)}_{A|k<1}, \pi^{r(ii)}_{A|k<1}\}$. Note that the equilibrium outcomes when the exclusive supply offer is accepted do not depend on k. Therefore, exclusion is possible, if condition (16) holds for $k = k'$. The following proposition shows that the possibility of exclusion depends not only on entrant D_E's efficiency but also on that of supplier U_A.

Proposition 2. *Suppose that the downstream firms differ in transformational technology of input A (*$m = 1$ *and* $k < 1$*) and that they are undifferentiated Bertrand competitors. Then, there exists an exclusion equilibrium when entrant* D_E *becomes sufficiently efficient (that is,* $k < k^*$*), where*

$$k^* = \frac{\pi^d}{\pi^*}. \tag{18}$$

Here, π^d *is the joint profit of* D_I *and* U_A *under the double marginalization problem, and* π^* *is the maximum value of such joint profit. More precisely,*

1. *For* $k^* \leq k < 1$*, entry is a unique equilibrium outcome, and*

2. *For* $k < k^*$*, the possibility of exclusion depends on the efficiency of* U_A*;*

   (a) *When* U_A *is sufficiently efficient,* $0 \leq c_A < \tilde{c}_A$*, exclusion is possible for* $0 < k < k^*$.

   (b) *When* U_A *is not too efficient,* $\tilde{c}_A \leq c_A$*, exclusion is possible for* $0 < k'' < k < k^*$*, if there exists* $k'' < k^*$ *that satisfies* $\pi^{r(ii)}_{A|k<1}(k'') = \pi^a_A + \Pi^a_I$*, where*

   $\tilde{c}_A$ *is a threshold value such that* $\pi^a_{A|_{c_A=0}} = \pi^a_A(\tilde{c}_A) + \Pi^a_I(\tilde{c}_A)$.

Figures 8 and 9 summarize the result in Proposition 2 under linear demand $Q(p) = (a - p)/b$, where $a > c_A + c_B$ and $b > 0$.[10] Under linear demand, we have $k^* = 3/4$, $k'' = ((a - c_B)2 - (a - c_A - c_B)\sqrt{6})/2c_A$, and $\tilde{c}_A = (3 - \sqrt{6})(a - c_B)/3 \simeq 0.1835(a - c_B)$. The result in Proposition 2 contrasts with those in the previous literature on anticompetitive exclusive dealings. In the previous literature, as the entrant becomes efficient, firms are unlikely to engage in anticompetitive exclusive dealings. In this paper, on the contrary, anticompetitive exclusive dealings are likely to be observed as the entrant becomes efficient. In other words, an exclusive contract operates like the Luddites.[11]

The result in Proposition 2 is derived from the negative relationship between entrant D_E's efficiency and the demand for input A. Equation (13) implies that the demand for input A decreases as entrant D_E becomes efficient (as k decreases) in Case (i). The socially efficient entry of D_E generates two effects. First, as in the case where the downstream firms differ in the cost of input B, D_E's entry generates downstream competition and increases the production level of final goods. This expands the demand for input A and increases supplier U_A's profit. Second, contrarily, D_E's entry decreases incumbent D_I's market share but increases its own market share—note that D_E demands a smaller amount of input A, unlike D_I. This reduces the total demand for input A, and hence, supplier U_A's profit. Therefore, the entry of the highly efficient D_E increases the profit of supplier U_A only slightly. This allows the downstream incumbent D_I to profitably compensate the upstream supplier's profit when such entry occurs, by using its monopoly profits under exclusive dealing.

Note that Figure 9 implies that the possibility of anticompetitive exclusive dealings depends on the upstream supplier U_A's efficiency: as supplier U_A becomes inefficient, the possibility of anticompetitive exclusive supply agreements decreases. This is because entrant D_E's efficient transformational technology reduces supplier U_A's production cost, which improves the latter's profit. As supplier U_A becomes less efficient, the benefit of such cost reduction increases for supplier U_A, which decreases the possibility of anticompetitive exclusive supply agreements.

[10] The precise statement and its proof are provided in a separate technical appendix.

[11] See, for example, Hobsbawm (1952) and Mokyr (1992).

4 Quantity Competition

This section considers the existence of anticompetitive exclusive dealings to deter the socially efficient entry of D_E when downstream firms compete in quantity. In this section, we use linear demand; that is, the inverse demand for the final product $P(Q)$ is given by a simple linear function:

$$P(Q) = a - bQ, \tag{19}$$

where Q is the output of the final product supplied by downstream firms and where $a > c_A + c_B$ and $b > 0$.

As in Section 3, in Section 4.1, we introduce a benchmark analysis where downstream firms have the same transformational technology of input A but differ in the costs of input B. In Section 4.2, we then analyze the case where downstream firms differ in the transformational technology of input A but incur the same costs on input B.

4.1 Benchmark: when downstream firms have the same transformational technology of input produced by the upstream supplier

Assume that downstream firms have the same transformational technology of input A but differ in costs of input B; that is, $k = 1$ and $m < 1$. We also assume that

$$\max\left\{0, \frac{-2(a - c_A) + 7c_B}{5c_B}\right\} < m < 1. \tag{20}$$

The first inequality implies that incumbent D_I does not exit the downstream market when entry occurs. The following proposition shows that exclusion is impossible as long as we assume that downstream firms have the same transformational technology of the input supplied by A.

Proposition 3. *Suppose that downstream firms have the same transformational technology of input A ($k = 1$ and $m < 1$) and compete in quantity. Then, incumbent D_I cannot deter socially efficient entry by using an exclusive supply contract.*

This result implies that the Chicago School argument is a highly robust result. As long as we assume that downstream firms have same transformational technology of input A, exclusion of the efficient entrant is impossible regardless of the type of downstream competition.

4.2 When downstream firms differ in the transformational technology of input produced by the upstream supplier

We now assume that downstream firms differ in the transformational technology of input A; that is, $k < 1$. For analytical simplicity, we assume that $m = 1$. For anticompetitive exclusive dealing to exist, we assume that $k > 1/2$. If this inequality does not hold, then D_E's entry does not increase supplier U_A's profit. From the above assumptions, we have

$$1/2 < k < 1. \tag{21}$$

Under undifferentiated Bertrand competition, the production level of incumbent D_I is always zero. On the contrary, under Cournot competition, the production level of D_I is positive and dependent on the efficiency of entrant D_E. To understand the effect of an improvement in D_E's efficiency on the demand for input A, consider the demand for input A given the input price w_A^r when entry occurs, $q_A^r(k, w_A^r) = Q_I^r(k, w_A^r) + kQ_E^r(k, w_A^r)$. By differentiating this equation with respect to k, we have

$$\frac{\partial q_A^r(k, w_A^r)}{\partial k} = \frac{\partial Q_I^r(k, w_A^r)}{\partial k} + Q_E^r(k, w_A^r) + \frac{\partial Q_E^r(k, w_A^r)}{\partial k}, \tag{22}$$

where $\partial Q_I^r(k, w_A^r)/\partial k = w_A^r/3b$, $Q_E^r(k, w_A^r) = (a - c_B - (2k-1)w_A^r)/2b$, and $\partial Q_E^r(k, w_A^r)/\partial k = -2w_A^r/3b$ under linear demand.

The first term on the right-hand side of equation (22) implies that an improvement of entrant D_E's efficiency reduces incumbent D_I's production level of final products. This effect reduces the demand for input A. The second term implies that the improvement of its efficiency directly reduces D_E's demand for input A. This effect becomes weaker in the case where D_E's efficiency is low and the input price is likely to be high because supplier U_A is inefficient. Finally, the third effect implies that an improvement in its efficiency increases D_E's production level of final products, and thus, D_E's demand for input A increases. This effect becomes stronger when the input price is high. Therefore, when entrant D_E and supplier U_A are inefficient, the demand for input A increases as entrant D_E becomes efficient. Under linear demand, we obtain the following results.

Lemma 5. *Suppose that downstream firms differ in the transformational technology of input*

A ($m = 1$ and $k < 1$) and compete in quantity. The equilibrium demand level for input A following D_E's entry has the following properties.

1. *The equilibrium demand level for input A following D_E's entry is always larger than the one when the entry does not occur for $1/2 < k < 1$.*

2. *As D_E becomes efficient (that is, k decreases), the equilibrium demand level for input A following such entry decreases, if supplier U_A is sufficiently efficient (that is, $c_A < (a - c_B)/2$ is sufficient). More precisely,*

   (a) *For $1/2 \leq k < 3/4$, the equilibrium demand level for input A always decreases, and*

   (b) *For $3/4 \leq k < 1$, the equilibrium demand level for input A decreases, if the upstream supplier U_A is sufficiently efficient, $0 \leq c_A < \check{C}_A(k)$, where*

$$\check{C}_A(k) = \frac{a - c_B}{2(2k - 1)}. \tag{23}$$

Figure 10 summarizes the result in Lemma 5. Lemma 5 implies that as under undifferentiated Bertrand competition, if we assume that D_E is more efficient than the incumbent with regard to the technology to transform input A into the final product, the highly efficient D_E's entry is not desirable for the upstream supplier U_A when U_A is efficient. The following proposition shows that this allows rational economic agents to engage in anticompetitive exclusive dealings.

Proposition 4. *Suppose that the downstream incumbent is less efficient than the entrant in terms of transformational technology of input A ($m = 1$ and $k < 1$). Then, incumbent D_I and supplier U_A engage in an exclusive supply agreement, if entrant D_E becomes sufficiently efficient. More precisely,*

1. *For $\hat{k} \leq k < 1$, entry is a unique equilibrium outcome, and*

2. *For $1/2 \leq k < \hat{k}$, exclusion is a unique equilibrium outcome, if the upstream supplier U_A is sufficiently efficient, that is, $0 \leq c_A < \overline{C}_A(k)$ where $\hat{k} \simeq 0.921543$, and*

$$\overline{C}_A(k) = \frac{(a-c_B)\Big(2k^3+3k^2+3k-7+3(1-k)\sqrt{3(-4k^4-12k^3+31k^2-26k+10)}\Big)}{(2k-1)(14k-13)(k^2-k+1)}. \quad (24)$$

Note that $\partial\overline{C}_A(k)/\partial k < 0$, $\overline{C}_A(k) \to 2(a-c_B)/3$ *as* $k \to 1/2$, *and* $\overline{C}_A(k) \to 0$ *as* $k \to \hat{k}$.

Figure 11 summarizes the result in Proposition 4. On comparing Figures 9 and 11, we observe a notable difference that the possibility of anticompetitive exclusion under Cournot competition is higher; that is, exclusion may arise even when $k > 3/4$. This result follows from the difference in the degree of demand expansion between the two types of competition. Compared with undifferentiated Bertrand competition, D_E's entry under Cournot competition leads to smaller demand expansion, because it partially solves the double marginalization problem. Therefore, D_E's entry leads to a smaller increase in supplier U_A's profit.

5 Discussion

This section briefly discusses the wholesale pricing of input A. In Section 5.1, we extend the analysis by allowing price discrimination by the upstream supplier. In Section 5.2, we discuss linear wholesale pricing.

5.1 Price discrimination

Thus far, we assumed that supplier U_A charges downstream firms a uniform price w_A^r. We briefly discuss how the results in Section 3.2 change if supplier U_A is able to discriminate on price when D_E enters the downstream market. For comparison purposes, we assume that $m = 1$, and $k < 1$. Then, if supplier U_A chooses input prices $w_{A|i}^r$ for D_i, where $i \in \{I, E\}$, the per unit costs of incumbent D_I and entrant D_E are denoted by $w_I^r = w_{A|I}^r + c_B$ and $w_E^r = kw_{A|E}^r + c_B$, respectively. Although we have assumed that entrant D_E must incur a sufficiently small fixed cost on entry, we now assume that entrant D_E always enters the downstream market in Stage 2 if the exclusive supply offer is rejected in Stage 1.

Consider the case where supplier U_A rejects the exclusive supply offer in Stage 1. In this case, entrant D_E enters the downstream market in Stage 2. In Stage 4, undifferentiated Bertrand competition occurs, which leads to monopolization by the downstream firm with the lower wholesale price. In equilibrium, supplier U_A optimally chooses a pair of input prices $(w^r_{A|I}, w^r_{A|E})$ such that $w^r_I = w^r_E$ (that is, $w^r_{A|E} = w^r_{A|I}/k$) and it earns

$$\begin{aligned}\pi^r_A &= \max_{w^r_{A|I}}(w^r_{A|I} - kc_A)Q(w^r_{A|I} + c_B) \\ &= \max_v (v - (kc_A + c_B))Q(v) \\ &= \pi^*(kc_A + c_B),\end{aligned} \tag{25}$$

where $v \equiv w^r_{A|I} + c_B$. In contrast, downstream firms earns zero profits. The result here implies that if supplier U_A can discriminate on price, then it can jointly maximize profits with D_E and earn all profits even under linear pricing.[12] By comparing such profits with the joint profit with D_E when U_A accepts the exclusive supply offer (11), it is easy to see that condition (7) never holds, and thus, exclusion becomes impossible.[13]

Proposition 5. *Suppose that the downstream firms differ in transformational technology of input A ($m = 1$ and $k < 1$) and that they are undifferentiated Bertrand competitors. Suppose also that D_E always enters the market if the exclusive supply contract is rejected in Stage 1. If supplier U_A is allowed to discriminate on price, then incumbent D_I cannot deter socially efficient entry by using an exclusive supply contract.*

The intuitive logic is as follows. When supplier U_A can discriminate on price, it can extract profits of entrant D_E by setting $w^r_I = w^r_E$. In addition, supplier U_A can control the final product price by choosing input price $w^r_I = w^r_E = p^*(kc_A + c_B)$. Therefore, supplier U_A can jointly maximize profits with entrant D_E, when it rejects the exclusive supply offer and does not engage in exclusive supply agreements.

Proposition 5 and the result in Section 3 imply that the imposition of uniform pricing induces exclusion of an efficient entrant through an exclusive supply contract offered by an inefficient incumbent. That is, a ban on price discrimination, such as the famous Robinson–Patman Act, can protect smaller or otherwise weaker competitors. We believe that the result confirms the main results in Inderst and Valletti (2009), which show that the ban on price

[12]When downstream firms compete in quantity, joint profit maximization is impossible and these firms earn positive profits, although we basically obtain the same results. Because the entrant earns positive profits, D_E enters the market if the fixed cost of entry is sufficiently small.

[13]The result here implies that at the beginning of Stage 2, U_A may make a commitment to $w^r_{A|E}$ that covers the fixed cost for D_E's entry. Moreover, if two-part tariffs are possible, U_A may commit to the lower fixed fee.

discrimination in input markets benefits smaller firms but hurts more efficient, larger downstream firms when downstream firms engage in cost-reducing activities. Therefore, we can conclude that this paper shows another manner in which a ban on input price discrimination harms market environments.

5.2 Linear pricing contracts

Note that we believe that linear pricing contracts are common in the real world—for instance, in gasoline retailing and shipping industries (Lafontaine and Slade, 2013). Linear contracts are sometimes employed in manufacturing industries, although non-linear pricing contracts are useful in vertical coordination (Nagle and Hogan, 2005 and Blair and Lafontaine, 2005). As also documented in Iyer and Villas-Boas (2003, p.81), in practice, both the magnitude and incidence of two-part tariffs may be insignificant.[14]

6 Concluding Remarks

This paper examined anticompetitive exclusive supply agreements focusing on the transformational technology of inputs. Previous studies have not differentiated between the incumbent and entrants with regard to the transformational technology of the input produced by the upstream supplier, because they mainly analyze the entry deterrence in upstream markets. However, our study suggests that when we focus on the entry deterrence in downstream markets by considering exclusive supply contracts, then the difference in transformational technology of the input could be an important market element.

We find that the difference in measures to evaluate the downstream firms' efficiency turns out to be crucial. When the incumbent and entrant differ with regard to the transformational technology of the input produced by the upstream supplier, the downstream incumbent and the upstream supplier sign exclusive supply contracts to deter socially efficient entry, even in the framework of the Chicago School argument where a single seller, a single buyer, and a single entrant exist. In addition, the difference in transformational technology of the input

[14] Milliou, Petrakis, and Vettas (2009) provide a theoretical reason for employing linear contracts. Inderst and Valletti (2009) also explain real world examples in which linear contracts are employed.

produced by the upstream supplier changes the relationship between the entrant's efficiency and the possibility of exclusion: anticompetitive exclusive supply agreements are more likely to arise when the entrant is highly efficient.

This paper provides new implications for antitrust agencies: it is necessary to focus on the efficiency measure when we discuss the anti-competitiveness of exclusive supply agreements. Rather than only studying exclusive dealings by upstream firms, we need to consider how the transformational technology of input influences exclusive supply agreements. In addition, exclusion here is highly dependent on input price discrimination; a ban on input price discrimination makes exclusion possible. By interpreting this result differently, this paper provides an example that a ban on input price discrimination harms market environments.

There are several outstanding concerns requiring further research. The first concern is about this study's relationship with other studies on anticompetitive exclusive dealing. For example, we assume that an upstream supplier firm is a monopolist. By inverting the vertical relationship analyzed by Simpson and Wickelgren (2007) and Abito and Wright (2008), Oki and Yanagawa (2011) show that upstream competition allows the downstream incumbent to deter efficient entry with exclusive supply contracts. We predict that if we add upstream competition to our model, the likelihood of an exclusion equilibrium increases. The second is about the generality of our results. Although the analysis is presented in terms of parametric examples, the result might be valid in more general settings. We hope this study facilitates researchers in addressing these issues.

Appendix A: Proofs of Results in Price Competition

Proof of Proposition 1

Let $m < 1$ and $k = 1$. We explore the existence of anticompetitive exclusive dealing in Case (ii) where $p^{r(ii)}_{E|m<1} < w^{r(ii)}_{A|m<1} + c_B$. Because we have $p^{r(ii)}_{E|m<1} < w_A + c_B$ given w_A, we have $Q(p^{r(ii)}_{E|m<1}) > Q(w_A + c_B)$. This implies that

$$(w_A - c_A)Q(p^{r(ii)}_{E|m<1}) > (w_A - c_A)Q(w_A + c_B). \tag{26}$$

Therefore, we have $\pi^{r(ii)}_{A|m<1} > \pi^*(c_A + c_B) > \Pi^a_I + \pi^a_A$ and, exclusion is impossible.

Q.E.D.

Proof of Lemma 3

W show that at least one interior solution exists in the profit maximization problems in Case (i) and Case (ii) when the exclusive offer is rejected in Stage 1. For expositional simplicity, we denote $w = w_A^r(k)$ by $w = w(k)$,

$$p^*(kw + c_B) = w + c_B. \tag{27}$$

The profit maximization problems of U_A in the two cases are given as

$$\text{Case (i)} \qquad \max_w \,(w - c_A)kQ(w + c_B), \tag{28}$$

$$\text{Case (ii)} \qquad \max_w \,(w - c_A)kQ(p^*(kw + c_B)). \tag{29}$$

The first-order conditions are given as

$$\text{Case (i)} \qquad H^{(i)}(w) \equiv Q(w + c_B) + (w - c_A)Q'(w + c_B), \tag{30}$$

$$\text{Case (ii)} \qquad H^{(ii)}(w) \equiv Q(p^*(kw + c_B)) + (w - c_A)kQ'(p^*(kw + c_B))p^{*\prime}(kw + c_B). \tag{31}$$

There are two domains $[c_A, w_A^r(k)]$ and $[w_A^r(k), \infty)$. Note that each maximization problem has a unique interior solution on the domain $[c_A, \infty)$ because we assume that $Q'(p) < 0$ and $Q''(p) \leq 0$. However, there exists a possibility of a corner solution where problem in Case (i) has an interior solution on the domain $[w(k), \infty)$ and problem in Case (ii) has an interior solution on the domain $[c_A, w(k)]$. In such case, the profit of U_A is maximized at $w = w_A^r(k)$. We explore whether the corner solution problem arises. Note that $w(k)$ is the optimal input price if and only if $H^{(i)}(w(k)) > 0$ and $H^{(ii)}(w(k)) < 0$. We show that two inequalities do not simultaneously hold. More precisely, we show that $H^{(ii)}(w(k)) > 0$ if $H^{(i)}(w(k)) > 0$.

Suppose that $H^{(i)}(w(k)) > 0$, that is,

$$H^{(i)}(w(k)) = Q(w(k) + c_B) + (w(k) - c_A)Q'(w(k) + c_B) > 0. \tag{32}$$

By using equation (27), $H^{(ii)}(w(k))$ can be rewritten as

$$H^{(ii)}(w(k)) = Q(w(k) + c_B) + (w(k) - c_A)kQ'(w(k) + c_B)p^{*\prime}(kw(k) + c_B). \tag{33}$$

To explore the property of above equation, we need to derive $p^{*\prime}(z)$. The first-order condition of the profit maximization problem (8) becomes

$$Q(p^*(z)) + (p^*(z) - z)Q'(p^*(z)) = 0. \tag{34}$$

The total differential of this equation leads to

$$p^{*\prime}(z) = \frac{Q'(p^*(z))}{2Q'(p^*(z)) + (p^*(z) - z)Q''(p^*(z))}. \tag{35}$$

By using equations (27), (32), (33), and (35), we have the following relation:

$$\begin{aligned} H^{(ii)}(w(k)) > {} & H^{(ii)}(w(k)) - H^{(i)}(w(k)) \\ & = -\frac{(w(k) - c_A)Q'(w(k) + c_B)\{(2 - k)Q'(p^*) + (1 - k)w(k)Q''(p^*)\}}{2Q'(p^*) + (1 - k)w(k)Q''(p^*)} \\ & > 0, \end{aligned} \tag{36}$$

where $p^* \equiv p^*(kw(k) + c_B)$. The last inequality holds because of the assumptions $Q'(p) < 0$ and $Q''(p) \leq 0$.

From the above discussion, we have $H^{(ii)}(w(k)) > 0$ if $H^{(i)}(w(k)) > 0$. This implies that in Case (ii) an interior solution always exists on the domain $[w^r_A(k), \infty)$ if in Case (i) the interior solution does not exist on the domain $[c_A, w^r_A(k)]$ and the corner solution appears; that is, we always have $w^{r(ii)}_{A|k<1} \in (w^r_A(k), \infty)$ if $w^{r(i)}_{A|k<1} = w^r_A(k)$. This also implies that at least one interior solution exists and that there are three possibilities concerning the optimal input price for U_A:

1. An interior solution exists only on the domain $[c_A, w^r_A(k)]$ in Case (i).

2. An interior solution exists only on the domain $[w^r_A(k), \infty)$ in Case (ii).

3. Interior solutions exist on the domains $[c_A, w^r_A(k)]$ in Case (i) and $[w^r_A(k), \infty)$ in Case (ii).

In the first and the second cases, we have the unique interior solutions. In the third case, we need to check which of the interior solutions is really optimal. The way to check it is provided in Section 3.2.

Q.E.D.

Proof of Lemma 4

For a sufficiently small k (as $k \to 0$), we have $\pi^{r(i)}_{A|k<1} < \pi^{r(ii)}_{A|k<1}$. On the contrary, for $k = 1$, we have $\pi^{r(i)}_{A|k<1} > \pi^{r(ii)}_{A|k<1}$. Because $\pi^{r(ii)}_{A|k<1}$ is strictly decreasing in k but $\pi^{r(i)}_{A|k<1}$ is strictly increasing in k, there exists $k' \in (0, 1)$ such that $\pi^{r(i)}_{A|k<1} = \pi^{r(ii)}_{A|k<1}$.

Q.E.D.

Proof of Proposition 5

We first show that input prices which satisfy $w^r_I < w^r_E$ (that is, $w^r_{A|I} < kw^r_{A|E}$) cannot be an equilibrium. Suppose in negation that U_A optimally chooses $w^r_{A|I} = v_I$ and $w^r_{A|E} = v_E$ such that $w^r_{A|I} < kw^r_{A|E}$, which allows D_I to supply its product and to choose the price at $p^r_I = kw^r_{A|E} + c_B$. Then U_A earns

$$\begin{aligned}\pi^r_{A|I} &= (w^r_{A|I} - c_A)Q(kw^r_{A|E} + c_B) \\ &= (v_I - c_A)Q(kv_E + c_B).\end{aligned} \tag{37}$$

However, if U_A instead chooses $w^r_{A|I} = kv_E$ and $w^r_{A|E} = v_I/k$, which satisfies $w^r_{A|I} > kw^r_{A|E}$ (that is, $kv_E > v_I$), D_E supplies its product and chooses the price at $p^r_E = w^r_{A|I} + c_B$. Under this input pricing, U_A earns

$$\begin{aligned}\pi^r_{A|E} &= (w^r_{A|E} - c_A)kQ(w^r_{A|I} + c_B) \\ &= (v_I - kc_A)Q(kv_E + c_B).\end{aligned} \tag{38}$$

This is larger than (37) because $k < 1$. This is a contradiction.

Second, we also show that we do not have $w^r_I > w^r_E$ in the equilibrium. Suppose in negation that U_A optimally chooses $w^r_I > w^r_E$. Then, by using $v \equiv w^r_{A|I} + c_B$, we have

$$\begin{aligned}\pi^r_{A|E} &= (kw^r_{A|E} - kc_A)Q(w^r_{A|I} + c_B) \\ &< (w^r_{A|I} - kc_A)Q(w^r_{A|I} + c_B) \\ &= (v - (kc_A + c_B))Q(v).\end{aligned} \tag{39}$$

This is a contradiction.

Q.E.D.

Appendix B: Proofs of Results in Quantity Competition

B.1 Equilibria in Subgames after Stage 1

We consider each of the possible subgames after Stage 1. In this Appendix, we consider the case of quantity competition. In B.1.1, we consider the case where an exclusive offer is accepted by the upstream supplier A. Then, in B.1.2, we consider the case where the exclusive offer is rejected by this supplier.

B.1.1 When the exclusive offer is accepted in Stage 1

The equilibrium demand level for input A becomes

$$q_A^a = Q_I^a = \frac{a - c_A - c_B}{4b}. \tag{40}$$

U_A earns (before compensation),

$$\pi_A^a = \frac{(a - c_A - c_B)^2}{8b}, \tag{41}$$

and D_I earns (before compensation),

$$\Pi_I^a = \frac{(a - c_A - c_B)^2}{16b}. \tag{42}$$

B.1.2 When the exclusive offer is rejected in Stage 1

When U_A rejects the exclusive supply offer in Stage 1, D_E enters the downstream market in Stage 2 and U_A deals with D_I and D_E. In Stage 3, U_A sets input prices for each downstream firm to maximize its profit by considering the production levels of downstream firms in Stage 4 given its input price; that is,

$$w_A^r = \arg\max_{w_A \geq c_A} (w_A - c_A)(Q_I^r(w_A) + kQ_E^r(w_A)), \tag{43}$$

subject to

$$Q_I^r(w_A) = \arg\max_{Q_I \geq 0} (a - b(Q_I + Q_E) - w_A - c_B)Q_I, \tag{44}$$

$$Q_E^r(w_A) = \arg\max_{Q_E \geq 0} (a - b(Q_I + Q_E) - kw_A - mc_B)Q_E. \tag{45}$$

In the equilibrium, U_A chooses the following input price for A:

$$w_A^r(k,m,c_A,c_B) = \frac{a(1+k) + 2c_A(k^2-k+1) - c_B(2(1+km)-(k+m))}{4(k^2-k+1)}, \tag{46}$$

D_I chooses the following output level,

$$Q_I^r(k,m,c_A,c_B) = \frac{a(5k^2-5k+2) - 2c_A(2-k)(k^2-k+1) + c_B(4k+2m+2k^2m+km-7k^2-4)}{12b(k^2-k+1)}, \tag{47}$$

and D_E chooses the following output level,

$$Q_E^r(k,m,c_A,c_B) = \frac{a(2k^2-5k+5) - 2c_A(2k-1)(k^2-k+1) + c_B(k+7m-4k^2m+4km+2k^2+2)}{12b(k^2-k+1)}. \tag{48}$$

The demand for input A becomes

$$\begin{aligned} q_A^r(k,m,c_A,c_B) &= Q_I^r(k,m,c_A,c_B) + kQ_E^r(k,m,c_A,c_B) \\ &= \frac{a(1+k) - 2c_A(k^2-k+1) + c_B(k+m-2km-2)}{6b}. \end{aligned} \tag{49}$$

U_A earns

$$\pi_A^r(k,m,c_A,c_B) = \frac{(a(1+k) - 2c_A(k^2-k+1) + c_B(k+m-2km-2))^2}{24b(k^2-k+1)}, \tag{50}$$

D_I earns

$$\Pi_I^r(k,m,c_A,c_B) = \frac{(a(5k^2-5k+2) - 2c_A(2-k)(k^2-k+1) + c_B(4k+2m+2k^2m+km-7k^2-4))^2}{144b(k^2-k+1)}, \tag{51}$$

and D_E earns

$$\Pi_E^r(k,m,c_A,c_B) = \frac{(a(2k^2-5k+5) - 2c_A(2k-1)(k^2-k+1) + c_B(k+7m-4k^2m+4km+2k^2+2))^2}{144b(k^2-k+1)}. \tag{52}$$

B.2 Proofs of Results

Proof of Proposition 3

Let $k = 1$. Next, we explore whether an exclusion equilibrium exists. Let $G(1,m,c_A,c_B) = \pi_A^a(c_A,c_B) + \Pi_A^a(c_A,c_B) - (\pi_A^r(1,m,c_A,c_B) + \Pi_A^r(1,m,c_A,c_B))$. By differentiating $G(1,m,c_A,c_B)$ with respect to m, we have

$$\frac{\partial G(1,m,c_A,c_B)}{\partial m} = \frac{c_B(2(a-c_A) - c_B(31m-29))}{72b} \geq 0, \tag{53}$$

for all $0 \leq m \leq 1$ and for all $0 \leq c_A < a$ and $0 \leq c_B < a$, such that $0 \leq c_A + c_B < a$. This implies that if we have $G(1, 1, c_A, c_B) < 0$, then we always have $G(1, m, c_A, c_B) < 0$. For $m = 1$, we have

$$G(1, 1, c_A, c_B) = -\frac{(a - c_A - c_B)^2}{144b} < 0. \tag{54}$$

Therefore, D_I cannot deter D_E when downstream firms have the same transformational technology.

Q.E.D.

Proof of Lemma 5

Let $m = 1$. We first compare the equilibrium demand levels for input A. From equations (40) and (49), we have

$$q_A^r(k, m, c_A, c_B) - q_A^a(k, m, c_A, c_B) = \frac{(2k - 1)(a + c_A(1 - 2k) + c_B(1 - 2m))}{12b} > 0, \tag{55}$$

for all $0 < m < 1$ and $1/2 < k \leq 1$ (see (21)) because we have $a > c_A + c_B$. Therefore, the equilibrium demand level for input A when U_A rejects the exclusive supply offer is always higher than the one when U_A accepts the exclusive supply offer.

We next explore the relationship between D_E's efficiency and the demand for input A. By differentiating equation (49), we have

$$\frac{\partial q_A^r(k, 1, c_A, c_B)}{\partial k} = \frac{a + 2c_A(1 - 2k) - c_B}{6b}. \tag{56}$$

Equation (56) has positive value for $0 \leq c_A < \check{C}_A(k)$. Therefore, as the efficiency of D_E increases (that is, k decreases), the demand for input A decreases if we have $0 \leq c_A < \check{C}_A(k)$.

Q.E.D.

Proof of Proposition 4

Let $m = 1$. As in the proof of Proposition 1, we explore whether an exclusion equilibrium exists by examining whether inequality holds. Inequality (7) holds if and only if we have $0 \leq c_A < \overline{C}_A$. Therefore, an exclusion equilibrium exists for $0 \leq c_A < \overline{C}_A$.

Q.E.D.

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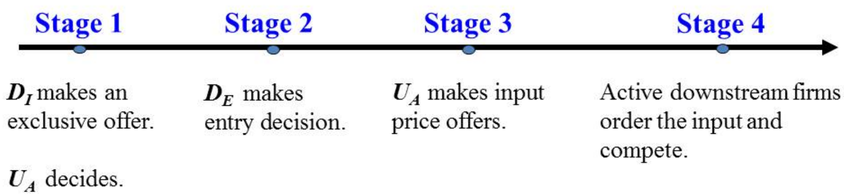

Figure 1: Time line

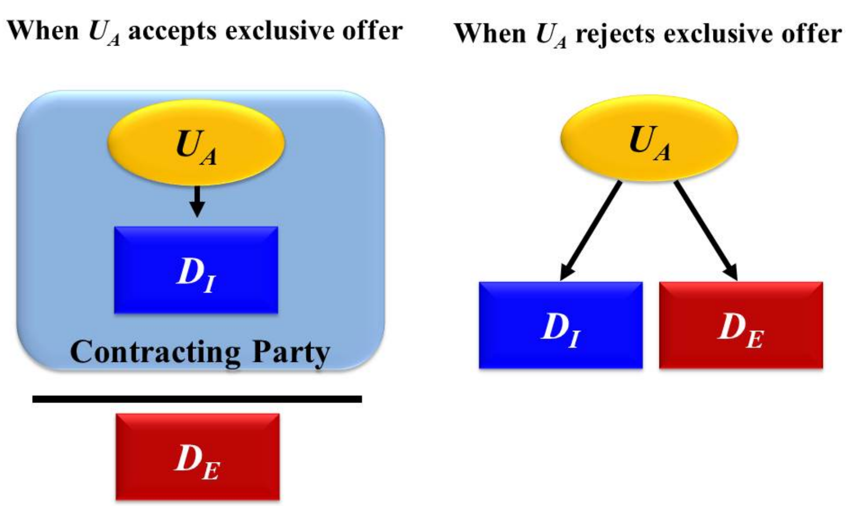

Figure 2: Wholesale price offers in Stage 3

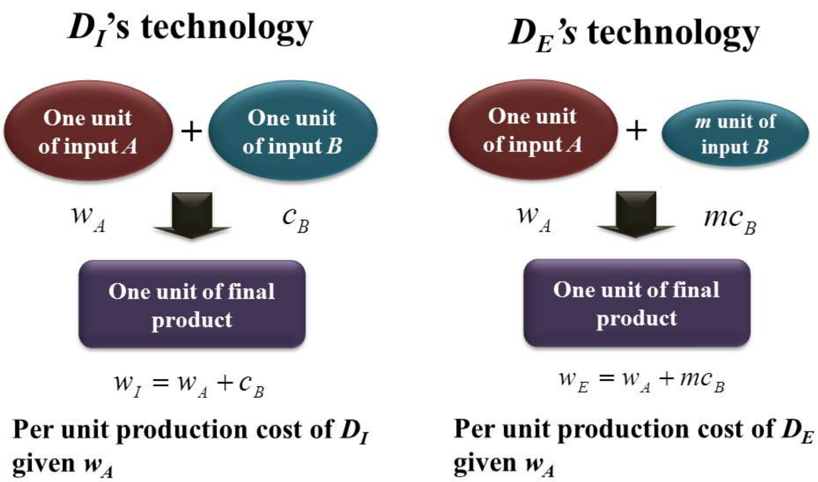

Figure 3: Per unit production costs when downstream firms have same transformational technologies of input A

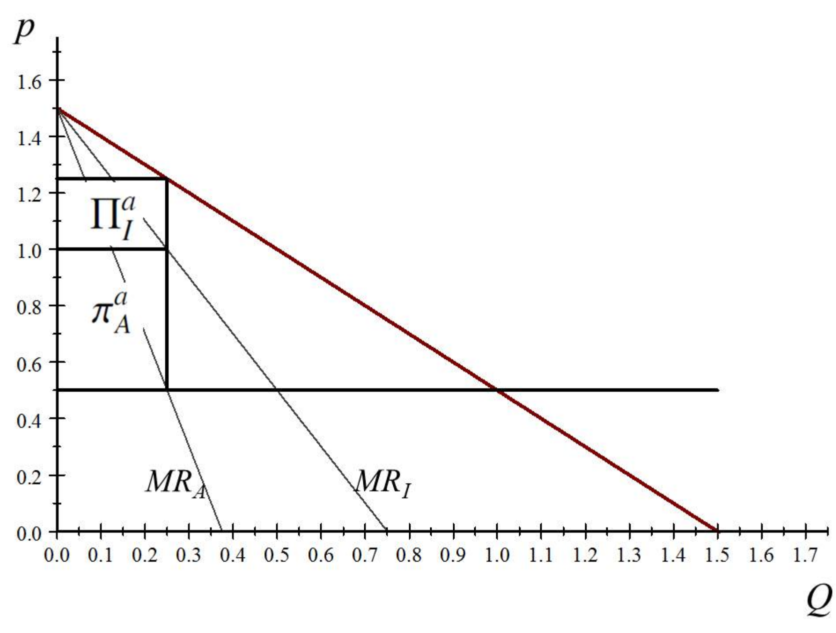

Figure 4: Equilibrium under exclusion ($a = 3/2$, $b = 1$, $c_A = 0$ and $c_B = 1/2$)

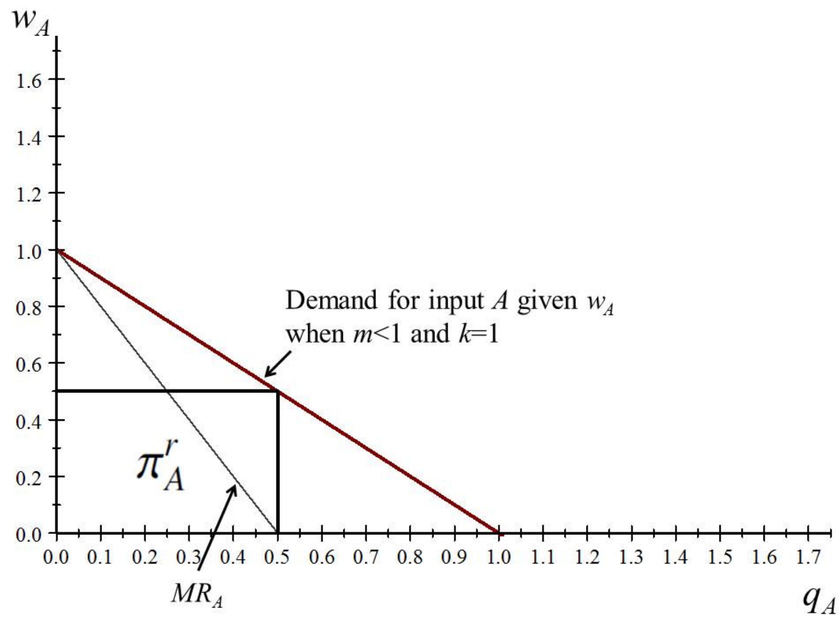

Figure 5: Equilibrium under entry for $m < 1$ and $k = 1$ ($a = 3/2$, $b = 1$, $c_A = 0$ and $c_B = 1/2$)

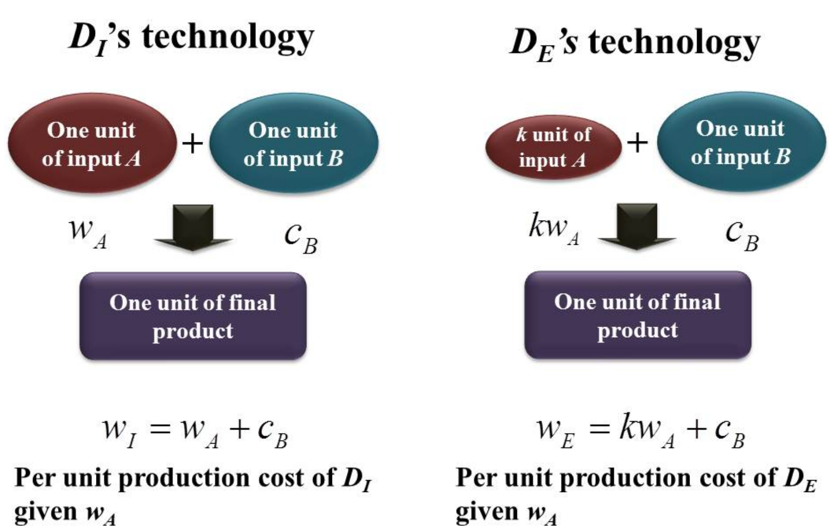

Figure 6: Per unit production costs when downstream firms differs in transformational technologies of input A

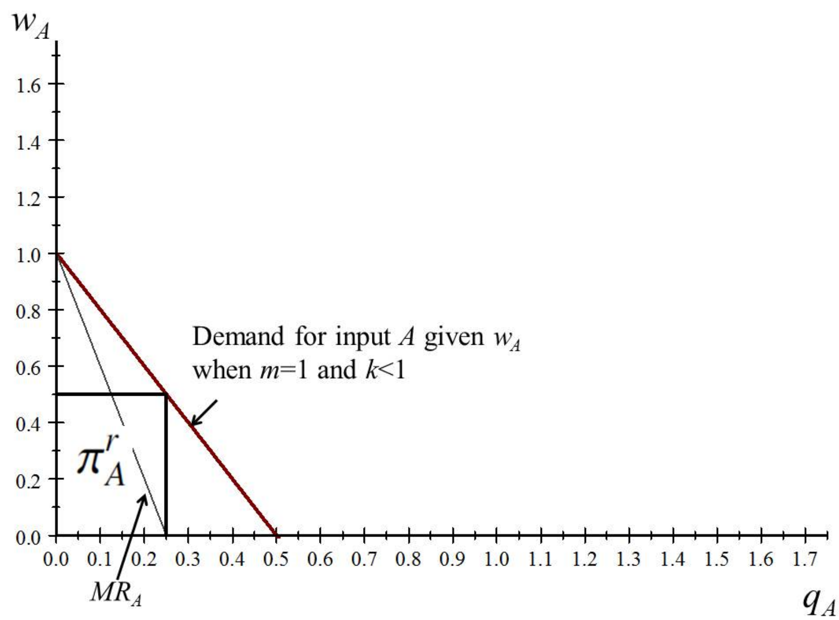

Figure 7: Equilibrium under entry for $m = 1$ and $k = 1/2$ ($a = 3/2$, $b = 1$, $c_A = 0$ and $c_B = 1/2$)

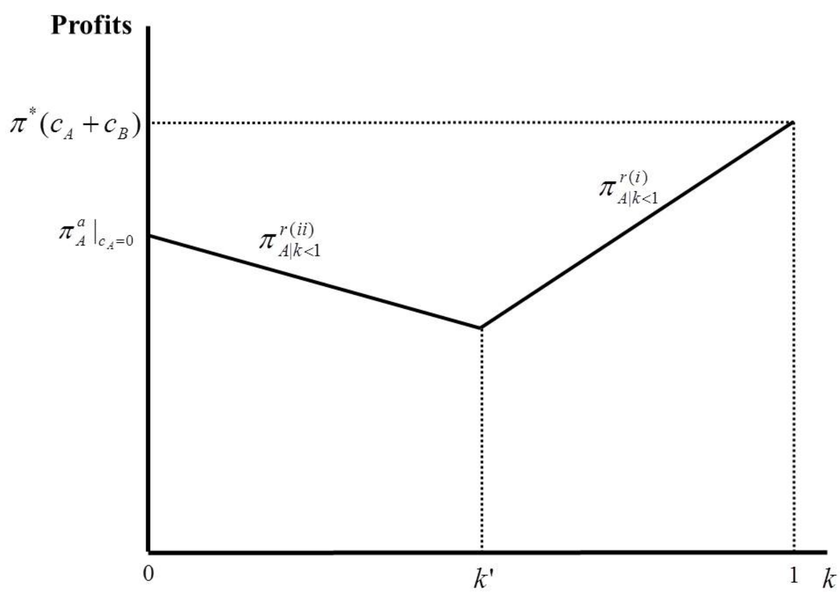

Figure 8: Properties of max $\{\pi^{r(i)}_{A|k<1}, \pi^{r(ii)}_{A|k<1}\}$

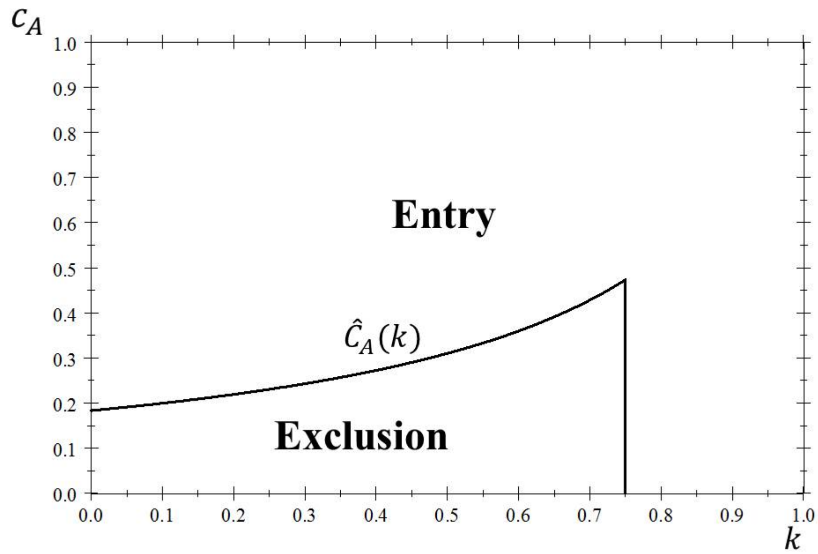

Figure 9: Results of Proposition 2 under linear demand ($a - c_B = 1$)

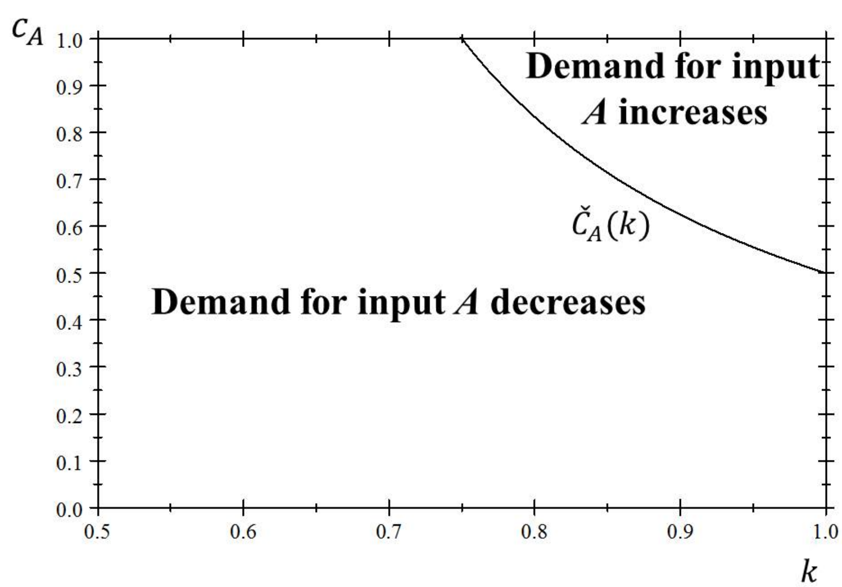

Figure 10: Results of Lemma 5: an increase or decrease in the demand for input A as the entrant becomes efficient ($a - c_B = 1$)

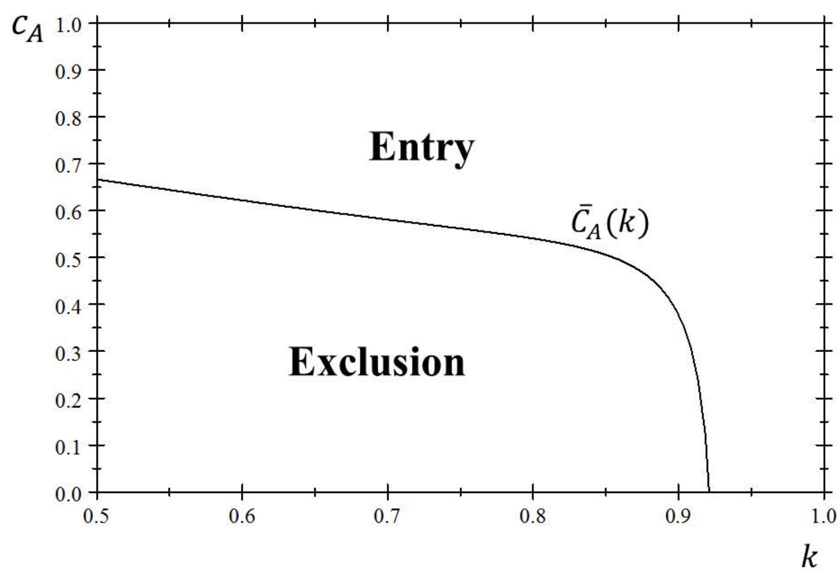

Figure 11: Results of Proposition 4 ($a - c_B = 1$)

A Technical Appendix for How Does Downstream Firms' Efficiency Affect Exclusive SupplyAgreements?

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Abstract

In this Appendix, we provide equilibrium outcomes in the subgame following the supplier's decisions and explore the possibility of exclusion under linear demand in Kitamura, Matsushima, and Sato (2013). The equilibrium outcomes in the subgame following Stage 1 is provided in Appendix A. Appendix B provides Remark 1 and its proof.

Assumption 1. *Consider the following linear demand; $Q(p) = (a - p)/b$, where $a > c_A + c_B$ and $b > 0$.*

A Equilibria in Subgames after Stage 1

We consider each of the possible subgames after Stage 1. In A.1, we consider the case where an exclusive offer is accepted by the upstream supplier A. Then, in A.2, we consider the case where the exclusive offer is rejected by this supplier.

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A.1 When the exclusive offer is accepted in Stage 1

The equilibrium demand level for input A becomes

$$q_A^a = Q_I^a = \frac{a - c_A - c_B}{4b}. \tag{A.1}$$

The upstream supplier U_A earns (before compensation),

$$\pi_A^a = \frac{(a - c_A - c_B)^2}{8b}, \tag{A.2}$$

and the downstream incumbent D_I earns (before compensation),

$$\Pi_I^a = \frac{(a - c_A - c_B)^2}{16b}. \tag{A.3}$$

A.2 When the exclusive offer is rejected in Stage 1 for $m = 1$ and $k < 1$

Let $m = 1$. As we have seen in Section 3.2, there are two types of equilibria in the subgame after the exclusive offer is rejected in Stage 1. We first consider Case (i). In Case (i), the upstream supplier U_A earns

$$\pi_{A|k<1}^{r(i)} = k\frac{(a - c_A - c_B)^2}{4b}, \tag{A.4}$$

the downstream incumbent D_I earns

$$\Pi_{I|k<1}^{r(i)} = 0, \tag{A.5}$$

and entrant D_E earns

$$\Pi_E^{r(i)} = \frac{((1 - k)(a - c_A - c_B)(a + c_A - c_B)}{b}. \tag{A.6}$$

Next, we consider Case (ii).[1]Given w_A, D_E chooses the following price.

$$p^*(w_A + c_B) = \frac{a + kw_A + c_B}{2}. \tag{A.7}$$

The equilibrium input price becomes

$$w_{A|k<1}^{r(ii)} = \frac{a - kc_A - c_B}{2k}. \tag{A.8}$$

[1]See also Proof of Proposition 2 for profit maximization problem.

The equilibrium price of final product becomes

$$p^{r(ii)}_{E|k<1} = \frac{3a + kc_A + c_I}{4}. \tag{A.9}$$

The upstream supplier U_A earns (before compensation),

$$\pi^{r(ii)}_{A|k<1} = \frac{(a - kc_A - c_B)^2}{8b}, \tag{A.10}$$

and the downstream incumbent D_I earns (before compensation),

$$\Pi^{r(ii)}_{I|k<1} = 0, \tag{A.11}$$

and entrant D_E earns

$$\Pi^{r(ii)}_{E|k<1} = \frac{(a - kc_A - c_B)^2}{16b}. \tag{A.12}$$

At the beginning of Stage 3, the supplier U_A chooses the equilibrium type. For $0 < k \leq 1/2$, we always have $\pi^{r(i)}_{A|k<1} < \pi^{r(ii)}_{A|k<1}$. In contrast, for $1/2 < k < 1$, we have $\pi^{r(i)}_{A|k<1} < \pi^{r(ii)}_{A|k<1}$ if $c_A > \acute{C}_A(k)$, where

$$\acute{C}_A(k) = \frac{(a - c_B)(k - \sqrt{2k}(1 - k))}{k(2 - k)}, \tag{A.13}$$

and where $\partial \acute{C}_A(k)/\partial k > 0$, $\acute{C}_A(1/2) = 0$, and $\acute{C}_A(1) = 1$.

We now examine whether input prices in each equilibrium satisfy the definition of each case. We first check Case (i). For $0 < k < 1$, we have $p^*(w^{r(i)}_{A|k<1} + c_B) > w^{r(i)}_{A|k<1} + c_B$ if $c_A < \breve{C}_A(k)$, where

$$\breve{C}_A(k) = \frac{k(a - c_B)}{2 - k}, \tag{A.14}$$

where $\partial \breve{C}_A(k)/\partial k > 0$, $\breve{C}_A(0) = 0$, and $\breve{C}_A(1) = 1$. Because we have

$$\breve{C}_A(k) - \acute{C}_A(k) = \frac{(a - c_B)(\sqrt{2k} - k)(1 - k)}{k(2 - k)} > 0, \tag{A.15}$$

for all $0 < k < 1$, whenever we have $\pi^{r(i)}_{A|k<1} > \pi^{r(ii)}_{A|k<1}$, the equilibrium input price in Case (i) satisfies $p^{r(i)}_{E|k<1} = w^{r(i)}_{A|k<1} + c_B$. We next check Case (ii). For $0 < k < 2/3$, we always have $p^{r(ii)}_{E|k<1} < w^{r(ii)}_{A|k<1} + c_B$. For $2/3 < k < 1$, we have $p^{r(ii)}_{E|k<1} < w^{r(ii)}_{A|k<1} + c_B$ if $c_A < \grave{C}_A(k)$ where

$$\grave{C}_A(k) = \frac{(a - c_B)(3k - 2)}{k(2 - k)}, \tag{A.16}$$

and where $\partial \grave{C}_A(k)/\partial k > 0$, $\grave{C}_A(2/3) = 0$, and $\grave{C}_A(1) = 1$. Because we have

$$\acute{C}_A(k) - \grave{C}_A(k) = \frac{(a - c_B)(2 - \sqrt{2k})(1 - k)}{k(2 - k)} > 0, \tag{A.17}$$

for all $2/3 < k < 1$, whenever we have $\pi^{r(i)}_{A|k<1} < \pi^{r(ii)}_{A|k<1}$, the equilibrium input price in Case (ii) satisfies $p^{r(ii)}_{E|k<1} < w^{r(ii)}_{A|k<1} + c_B$. Therefore, for all $0 < k \leq 1/2$ we have the equilibrium in Case (ii). On the other hand, for $1/2 < k < 1$ we have the equilibrium in Case (i) (Case (ii)) if $c_A \leq \acute{C}_A(k)$ ($c_A > \acute{C}_A(k)$).

B Existence of Exclusion

Remark 1. *Under linear demand, exclusion of the highly efficient entrant D_E ($k < 3/4$) occurs if the supplier U_A is sufficiently efficient ($c_A < 0.18(a - c_B)$ is sufficient). More precisely,*

1. *For $3/4 \leq k < 1$, entry is a unique equilibrium outcome, and*
2. *For $0 < k < 3/4$, exclusion is a unique equilibrium outcome, if the upstream supplier U_A is sufficiently efficient, that is, $0 \leq c_A < \hat{C}_A(k)$ where*

$$\hat{C}_A(k) = \frac{(a - c_B)(\sqrt{6} - 2)}{\sqrt{6} - 2k}. \tag{B.1}$$

Note that $\partial \hat{C}_A(k)/\partial k > 0$, $\hat{C}_A(k) \to (3 - \sqrt{6})(a - c_B)/3 \simeq 0.1835(a - c_B)$ as $k \to 0$, and $\hat{C}_A(k) \to 2(6 - \sqrt{6})(a - c_B)/15 \simeq 0.4734(a - c_B)$ as $k \to 3/4$.

B.1 Proof of Remark 1

If the equilibrium outcomes in Case (i) arise on the equilibrium path when the exclusive supply offer is rejected, condition (7) holds for $k < 3/4$. In contrast, if the equilibrium outcomes in Case (ii) arise on the equilibrium path, condition (7) holds for $0 \leq c_A < \hat{C}_A(k)$.

Q.E.D.