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**HOW DOES DOWNSTREAM
FIRMS' EFFICIENCY AFFECT
EXCLUSIVE SUPPLY AGREEMENTS?**

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

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Abstract

This study 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 can decrease, 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.

JEL classifications code: L12, L41, L42.

Keywords: Antitrust policy; Entry deterrence; Exclusive supply contracts; Transformational technology.

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1 Introduction

Among contracts concerned with vertical restraints (e.g., exclusive contracts, loyalty rebates, slotting fees, resale price maintenance, quantity fixing, and tie-ins),¹ exclusive contracts have long been controversial,² because, once signed, these can deter efficient entrants. Thus, 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.³ In rebuttal of the Chicago School argument, post-Chicago economists indicate specific circumstances under which anticompetitive exclusive dealings occur.⁴ 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)).

Although these studies investigate situations in which an upstream incumbent makes exclusive offers to downstream firms, in real business situations, downstream firms offer exclusive supply contracts to upstream firms. First, in the relationships between an input supplier and final good producers, the U.S. Federal Trade Commission (FTC) stopped a large drug maker from enforcing 10-year exclusive supply agreements for an essential ingredient.⁵ Second, in the relationships between a final good producer and retailers, the FTC stopped a large

¹See, for example, Rey and Tirole (1986), Rey and Vergé (2010), and Asker and Bar-Issac (forthcoming). See also Rey and Tirole (2007) and Rey and Vergé (2008) for surveys of vertical restraints.

²Exclusive dealing agreements take various forms such as exclusive territories and exclusive rights (see, for instance, Mathewson and Winter (1984), Rey and Stiglitz (1995), and Matsumura (2003)).

³For the impact of the Chicago School argument on antitrust policies, see Motta (2004) and Whinston (2006).

⁴In 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.

⁵*FTC v. Mylan Laboratories, Inc., Cambrex Corporation, Profarmaco S.r.l., and Gyma Laboratories of America, Inc.*, No.X990015-1 (<http://www.ftc.gov/os/caselist/x990015ddc.shtml>).

toy retailer from preventing toy manufacturers from selling to warehouse clubs.⁶ More recently, the Japan Fair Trade Commission stopped an online gaming company from preventing mobile game developers from providing their games through a rival online gaming company.⁷ Hence, this study aims to ascertain the existence of anticompetitive exclusive supply contracts that prevent an upstream supplier from selling inputs to a new downstream entrant.

This study presents a model of anticompetitive exclusive supply contracts by inverting the vertical relationship in the Chicago School argument. The presented 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 exclusive 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 an efficiency measure to evaluate the efficiency of the incumbent and entrant downstream firms. We introduce the measure 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, in terms of per unit production cost, the entrant is more efficient than the incumbent. Note that the presented model differs not only in relation to the market structure where exclusion occurs, but also in the efficiency measure of the incumbent and entrant. Previous studies on anticompetitive exclusive contracts assume that the (exogenous) marginal cost of an upstream entrant is lower than that of an upstream incumbent. However, these studies do not consider the efficiency measure employed in our study.

This study shows that when the entrant is efficient in terms of the transformational technology of an input produced by the upstream supplier, the incumbent and the upstream sup-

⁶*Toys “R” Us, Inc., v. FTC*, No.98-4107 (<http://www.ftc.gov/os/adjpro/d9278/toyrus.pdf>). Another antitrust case was *The Garment District, Inc., v. Belk Stores Service, Inc., Mathews-Belk Company, Jantzen, Inc.*, No.85-2362 (<https://bulk.resource.org/courts.gov/c/F2/799/799.F2d.905.85-2362.html>). See Comanor and Rey (2000) for detailed discussions.

⁷<http://www.jftc.go.jp/en/pressreleases/yearly-2011/jun/individual-000427.html>.

plier can 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. More precisely, when the entrant and the incumbent have similar efficiency levels, exclusion never occurs. However, as the entrant becomes increasingly efficient, exclusion can occur. 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. However, as the entrant becomes increasingly efficient, it demands a smaller quantity of the input produced by the upstream supplier. In addition, such entry decreases the market share of the downstream incumbent, which demands a larger quantity of the input produced by the upstream supplier.⁸ 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 study also shows that the relation between the likelihood of exclusion and the entrant's efficiency is non-monotonic; that is, exclusion is more (less) likely to occur if the entrant's efficiency is at an intermediate (significantly high) level. When the entrant becomes sufficiently efficient, it can monopolize the downstream market; in other words, the incumbent's existence does not constrain the entrant's pricing. Given this significant efficiency difference between the downstream firms, if the entrant's efficiency improves further, the price of final products decreases, and this leads to an expansion of the downstream market, which benefits the upstream supplier. Therefore, exclusion is less likely to occur if the efficiency level of the entrant is significantly high.

⁸If the downstream firms compete in quantity, an improvement in the entrant's efficiency gradually diminishes the market share of the downstream incumbent. If the downstream firms compete in price and the goods are perfect substitutes, the market share of the downstream incumbent is zero, that is, a drastic depression of its market share occurs.

Moreover, this study shows that exclusion is more likely to occur if the upstream supplier's efficiency is high, rather than if it is low. Although the existence of an entrant with more efficient technology than the incumbent decreases the demand for the input and the upstream supplier's profits, it also reduces the production cost of the upstream supplier, which improves this supplier's profits. However, this positive effect does not work well if the upstream supplier is highly efficient, and therefore, exclusion is more likely to occur in this case.

This study is related to the literature on anticompetitive exclusive dealings to deter upstream entrants.⁹ 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.¹⁰ They show that intense downstream competition reduces the possibility of exclusion. However, Simpson and Wickelgren (2007) and Abito and Wright (2008) point 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.¹¹

Wright (2008) and Argenton (2010) explore extended models of exclusion with down-

⁹Certain 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. Another motivation to consider exclusive dealing is to solve the commitment problem of 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).

¹⁰Fumagalli 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.

¹¹See also Wright's (2009) study, which corrects the result of Fumagalli and Motta (2006) in the case of two-part tariffs.

stream 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.¹² Furthermore, economists have recently analyzed anticompetitive exclusive dealings from an experimental perspective (Landeo and Spier, 2009, 2012, Smith, 2011, and Boone, Müller, and Suetens, forthcoming).

The remainder of this paper is organized as follows. In Section 2, we construct the basic environment of 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 Preliminaries

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.

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 an input exclusively produced by an upstream supplier

¹²Kitamura (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.

U . For this supplier, the marginal cost is $c \geq 0$ and w is the wholesale price of the input offered.

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

$$Q_I = q_I, \quad (1)$$

where Q_I (q_I) is the amount of the output (input) for incumbent D_I . The per unit production cost of downstream incumbent D_I , w_I , is denoted by

$$w_I = w. \quad (2)$$

In contrast, entrant D_E produces a unit of final product using k units of the input, where k is a positive constant. The transformation technology is denoted by

$$Q_E = q_E/k, \quad (3)$$

where Q_E (q_E) is the amount of the output (input) for entrant D_E . The per unit production cost of entrant D_E , w_E , is denoted by

$$w_E = kw. \quad (4)$$

Equation (4) implies that entrant D_E becomes efficient (that is, the per unit cost of entrant D_E decreases) as k decreases. We assume that $0 < k < 1$. On comparing (2) with (4), it is easy to see that entrant D_E is more efficient than incumbent D_I in terms of per unit production cost.

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 or to reduce defective products. Second, in the relationships between a final good producer and retailers, 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 .

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

in the transformational technology of the input, 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 has the smaller per unit production cost because it has an advantage, namely, the transformational technology of the competitively supplied input. In contrast, this study focuses on the existence of entry deterrence in the downstream market. The difference in transformational technology of input produced by the upstream supplier is 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 D_I offers an exclusive supply contract to the upstream supplier U . This contract involves some fixed compensation $x \geq 0$. Supplier U 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 offers a linear wholesale price of the input, w , to the active downstream firm(s). There are two cases (see Figure 2). If supplier U accepts the exclusive supply offer in Stage 1, then it offers the input price w^a only to incumbent D_I , where the superscript 'a' indicates that supplier U accepts the offer. In contrast, if supplier U rejects the exclusive supply offer in Stage 1, then it offers the input price w^r to all active downstream firms, where the superscript 'r' indicates that supplier U rejects the offer. We assume that supplier U 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 firms order the input and compete in the final market. If entry arises in Stage 2, then incumbent D_I and entrant D_E compete. Incumbent D_I 's profit in the case when supplier U accepts (rejects) the exclusive offer is denoted by Π_I^a (Π_I^r), and supplier U 's profit in the case when it accepts (rejects) the exclusive offer is denoted by π^a (π^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, incumbent D_I must earn higher operating profits under exclusive dealing, such that

$$\Pi_I^a - x \geq \Pi_I^r. \quad (5)$$

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

$$x + \pi^a \geq \pi^r. \quad (6)$$

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:

$$\Pi_I^a + \pi^a \geq \Pi_I^r + \pi^r. \quad (7)$$

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 .

3 Price Competition

This section considers the existence of anticompetitive exclusive dealings to deter the socially efficient entry of entrant D_E when downstream firms are undifferentiated Bertrand competitors. We assume that a general demand function $Q(p)$ is continuous and $Q'(p) < 0$. 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 $Q(p_i)$.¹³ For notational convenience, we define $p^*(z)$ and $\pi^*(z)$ as follows:

$$p^*(z) \equiv \arg \max_p (p - z)Q(p), \quad (8)$$

$$\pi^*(z) \equiv (p^*(z) - z)Q(p^*(z)), \quad (9)$$

where $z \geq 0$. As often assumed in industrial organization literature, we assume that the second-order condition is satisfied, that is,

Assumption 1. *The following inequality is satisfied:*

$$2Q'(p) + (p - z)Q''(p) < 0.$$

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

$$w^a = \arg \max_w (w - c)Q(p^*(w)). \quad (10)$$

We assume that the second-order condition is satisfied. Because we have $w^a > c$ in the equilibrium, the equilibrium price level $p^*(w^a)$ does not maximize the joint profits of incumbent D_I and supplier U ; that is, the double marginalization problem occurs.

$$\Pi_I^a + \pi^a = (p^*(w^a) - c)Q(p^*(w^a)) < \pi^*(c). \quad (11)$$

The entry deterrence allows incumbent D_I to earn higher operating profits. However, incumbent D_I and supplier U cannot maximize their joint profits, because of the double marginalization problem.

We next consider the case where supplier U rejects the exclusive supply offer in Stage 1. In this case, entrant D_E enters the downstream market in Stage 2. In Stage 4, given the

¹³This assumption avoids open-set problems in defining equilibria. See, for example, Abito and Wright (2008).

input price w^r , the downstream firms compete in price. Incumbent D_I earns zero profits in this subgame; that is, $\Pi_I^r = 0$ for all $0 < k < 1$. In addition, downstream competition leads to two types of equilibria in Stage 4. The undifferentiated Bertrand competition leads to the following outcomes:

Case (i) Incumbent D_I offers $p_I^{r(i)} = w^r$ and entrant D_E offers $p_E^{r(i)} = w^r$, if $p^*(kw^r) \geq w^r$.

Case (ii) Incumbent D_I offers $p_I^{r(ii)} = w^r$ and entrant D_E offers $p_E^{r(ii)} = p^*(kw^r)$, if $p^*(kw^r) \leq w^r$.

In Case (i) (if $p^*(kw^r) \geq w^r$), the marginal cost pricing of incumbent D_I binds the pricing of entrant D_E , which leads to $p_E^{r(i)} = w^r$. In Case (ii) (if $p^*(kw^r) \leq w^r$), the marginal cost pricing of incumbent D_I does not bind the pricing of entrant D_E , which leads to $p_E^{r(ii)} = p^*(kw^r)$.

By anticipating this pricing in Stage 4, supplier U optimally chooses its input price in Stage 3. Note that for each case, we have a unique interior solution $(w^{r(i)}, w^{r(ii)}) \in [c, \infty)^2$. Although each interior solution needs to satisfy the constraints $(w^{r(i)} \in [c, p^*(kw^{r(i)})]$ and $w^{r(ii)} \in [p^*(kw^{r(ii)}), \infty)$), we first characterize the properties of each interior solution on the full domain $[c, \infty)$ in Lemmas 1 and 2. We then consider the constraints of each interior solution in Lemma 3 and finally characterize the properties of supplier U 's profit in Lemma 4.

From now on, we characterize each interior solution on the full domain $[c, \infty)$. First, in Case (i), supplier U faces its input demand

$$q_E^{r(i)} = kQ(p_E^{r(i)}) = kQ(w^r). \quad (12)$$

Given this input demand, the upstream supplier U optimally chooses input price $w^{r(i)} \equiv \arg \max_{w^r} k(w^r - c)Q(w^r)$ in Stage 3. By the maximization problem, we have the profit of supplier U as follows:

$$\pi^{r(i)} = \max_{w^r} k(w^r - c)Q(w^r) = k\pi^*(c). \quad (13)$$

Note that when $k = 1$, $\pi^{r(i)} = \pi^*(c)$, which implies that entrant D_E 's entry allows supplier U to earn profits equivalent to the maximized value of the joint profits of supplier U and incumbent D_I . From equations (11) and (13), we identify the following properties.

Lemma 1. *Under the interior solution $w^{r(i)} \in [c, \infty)$, $\pi^{r(i)}$ have the following properties:*

1. $\pi^{r(i)}$ is strictly increasing in k but decreasing in c .
2. As $k \rightarrow 1$, $\pi^{r(i)} \rightarrow \pi^*(c)$, which is strictly larger than $\Pi_I^a + \pi^a$.
3. As $k \rightarrow 0$, $\pi^{r(i)} \rightarrow 0$.

Second, in Case (ii), supplier U faces its input demand $q_E^{r(ii)} = kQ(p^*(kw^r))$. Given this input demand, supplier U chooses the input price to maximize its profit in Stage 3;

$$\pi^{r(ii)} = \max_{w^r} (w^r - c)kQ(p^*(kw^r)) = \max_w \{wQ(p^*(w)) - kcQ(p^*(w))\}. \quad (14)$$

From equations (10) and (14), we identify the following properties.

Lemma 2. *Under the interior solution $w^{r(ii)} \in [c, \infty)$, $\pi^{r(ii)}$ have the following properties:*

1. $\pi^{r(ii)}$ is strictly decreasing in k and c .
2. As $k \rightarrow 1$, $\pi^{r(ii)} \rightarrow \pi^a$.
3. For any $c \geq 0$, as $k \rightarrow 0$, $\pi^{r(ii)} \rightarrow \pi^a|_{c=0}$.
4. For $c = 0$, $\pi^{r(ii)} = \pi^a|_{c=0}$,

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

We now characterize these two equilibria on two domains, $[c, w^r(k)]$ and $[w^r(k), \infty)$, where $w^r(k)$ is the input price satisfying

$$p^*(kw^r(k)) = w^r(k)$$

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. *For Cases (i) and (ii), at least one of the following holds, namely, $w^{r(i)} \in (c, w^r(k))$ or $w^{r(ii)} \in (w^r(k), \infty)$.*

Because we have $\pi^{r(i)} = \pi^{r(ii)}$ if we set $w^{r(i)}$ and $w^{r(ii)}$ at $w^r(k)$, we can conclude that one of the interior solutions mentioned above becomes the optimal solution of supplier U in equilibrium. Therefore, exclusion is possible regardless of equilibrium types if we have

$$\Pi_I^a + \pi^a > \max \{\pi^{r(i)}, \pi^{r(ii)}\}. \quad (15)$$

The following lemma characterizes the properties of $\max \{\pi^{r(i)}, \pi^{r(ii)}\}$.

Lemma 4. *$\max \{\pi^{r(i)}, \pi^{r(ii)}\}$ has the following properties.*

1. *It is strictly decreasing in c .*
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*

$$\max \{\pi^{r(i)}, \pi^{r(ii)}\} = \begin{cases} \pi^{r(ii)} & \text{if } 0 < k \leq k', \\ \pi^{r(i)} & \text{if } k' < k < 1. \end{cases} \quad (16)$$

Figure 3 summarizes the property of $\max \{\pi^{r(i)}, \pi^{r(ii)}\}$. Note that the equilibrium outcomes when the exclusive supply offer is accepted do not depend on k . Therefore, exclusion is possible, if condition (15) holds for $k = k'$.

By combining the above arguments, we have the following proposition:

Proposition 1. *Suppose that the downstream firms are undifferentiated Bertrand competitors. Then, there can be an exclusion equilibrium when entrant D_E becomes efficient (that is, $k < k^*$), where*

$$k^* \equiv \frac{\Pi_I^a + \pi^a}{\pi^*(c)}. \quad (17)$$

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 supplier U ;

(a) When supplier U is sufficiently efficient, $0 \leq c < \tilde{c}$, exclusion is possible for $0 < k < k^*$, where $\tilde{c}$ is a threshold value such that $\pi^a|_{c=0} = \Pi_I^a + \pi^a$.

(b) When supplier U is not too efficient, $\tilde{c} \leq c$, exclusion is possible for $0 < k'' < k < k^*$, if there exists $k'' < k^*$ that satisfies $\pi^{r(ii)} = \Pi_I^a + \pi^a$.

This proposition implies that the possibility of exclusion depends not only on entrant D_E 's efficiency but also on that of supplier U . To clarify the property of Proposition 1, we show the results in Proposition 1 under a linear demand $Q(p) = (a - p)/b$, where $a > c$ and $b > 0$.

Remark 1. Under linear demand, exclusion of the highly efficient entrant D_E ($k < 3/4$) occurs if supplier U is sufficiently efficient ($c < 0.18a$ 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 is sufficiently efficient, that is, $0 \leq c < \hat{C}(k)$ where

$$\hat{C}(k) = \frac{a(\sqrt{6} - 2)}{\sqrt{6} - 2k}. \quad (18)$$

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

Figure 4 summarizes the result in Proposition 1 under linear demand. Under linear demand, we have $k^* = 3/4$, $k'' = (2a - (a - c)\sqrt{6})/2c$, and $\tilde{c} = (3 - \sqrt{6})a/3 \simeq 0.1835a$.

The result in Proposition 1 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 study, 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.¹⁴

¹⁴See, for example, Hobsbawm (1952) and Mokyr (1992).

The result in Proposition 1 is derived from the negative relationship between entrant D_E 's efficiency and the demand for the input. Equation (12) implies that the demand for the input decreases as entrant D_E becomes efficient (as k decreases) in Case (i). The socially efficient entry of entrant D_E generates two effects. First, entrant D_E 's entry generates downstream competition and increases the production level of final goods. This expands the demand for the input and increases supplier U 's profit. Second, contrarily, entrant D_E 's entry decreases incumbent D_I 's market share but increases its own market share—note that entrant D_E demands a smaller amount of the input, unlike incumbent D_I . This reduces the total demand for the input, and hence, supplier U 's profit. Therefore, the entry of the highly efficient entrant D_E increases the profit of supplier U 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.

However, Figure 4 also shows that the relation between the likelihood of exclusion and entrant D_E 's efficiency is non-monotonic; that is, exclusion is more (less) likely to be observed for the intermediate (significantly high) level of entrant D_E 's efficiency. When entrant D_E becomes sufficiently efficient, the equilibrium outcome under entry becomes Case (ii) and entrant D_E can monopolize the downstream market. In Case (ii), the existence of incumbent D_I does not work as a constraint on entrant D_E 's pricing and a further efficiency improvement of entrant D_E decreases the price of final products, which then expands the production level of entrant D_E and the demand for the input. Therefore, for the significantly higher level of entrant D_E 's efficiency, the upstream supplier U welcomes an improvement in entrant D_E 's efficiency. This decreases the possibility of anticompetitive exclusion.

Note also that Figure 4 implies that the possibility of anticompetitive exclusive dealings depends on supplier U 's efficiency: as supplier U becomes inefficient, the possibility of anticompetitive exclusive supply agreements decreases. This is because entrant D_E 's efficient transformational technology reduces supplier U 's production cost, which improves the latter's profit. As supplier U becomes less efficient, the benefit of such cost reduction increases for supplier U , which decreases the possibility of anticompetitive exclusive supply agreements.

4 Quantity Competition

This section considers the existence of anticompetitive exclusive dealings to deter the socially efficient entry of entrant 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 that we use in Remark 1:

$$P(Q) = a - bQ,$$

where Q is the output of the final product supplied by downstream firms and where $a > c$ and $b > 0$. The following proposition shows that exclusion is possible not only under price competition but under Cournot competition as well.

Proposition 2. *Suppose that the downstream firms compete in quantity. Then, there can be an exclusion equilibrium as entrant D_E becomes efficient (that is, $k < \hat{k}$), where $\hat{k} \simeq 0.921543$. More precisely,*

1. *For $\hat{k} \leq k < 1$, entry is a unique equilibrium outcome, and*
2. *For $0 < k < \hat{k}$, exclusion is a unique equilibrium outcome, if the upstream supplier U is sufficiently efficient, that is, $0 \leq c < \bar{C}(k)$ and*

$$\bar{C}(k) = \begin{cases} \frac{a(2k^3 + 3k^2 + 3k - 7 + \sqrt{27(1-k)^2(-4k^4 - 12k^3 + 31k^2 - 26k + 10)})}{(2k-1)(14k-13)(k^2-k+1)} & \text{if } c < \dot{C}(k), \\ \hat{C}(k) & \text{if } c \geq \dot{C}(k). \end{cases} \quad (19)$$

where $\hat{C}(k)$ is in (18) and

$$\dot{C}(k) = \frac{a(k^2 - k + 1 - \sqrt{3(1-k)^2(k^2 - k + 1)})}{(2-k)(k^2 - k + 1)}. \quad (20)$$

Note that $\partial \dot{C}(k)/\partial k > 0$, $\dot{C}(k) \rightarrow 0$ as $k \rightarrow 1/2$, and $\dot{C}(k) \rightarrow 1$ as $k \rightarrow 1$ and that $\partial \bar{C}(k)/\partial k < (\geq) 0$ for $k > (\leq) \hat{k}(c_A)$, $\bar{C}(k) \rightarrow a(3 - \sqrt{6})/3 \simeq 0.1835a$ as $k \rightarrow 0$, and $\bar{C}(k) \rightarrow 0$ as $k \rightarrow \hat{k}$.

Figure 5 summarizes the result in Proposition 2. On comparing Figures 4 and 5, 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, entrant D_E 's entry under Cournot competition leads to smaller demand expansion, because it partially solves the double marginalization problem. Therefore, entrant D_E 's entry leads to a smaller increase in supplier U 's profit.

In addition, when both downstream firms produce a positive amount of final products (for $c < \dot{C}(k)$), the possibility of anticompetitive exclusion increases as entrant D_E becomes efficient. Under undifferentiated Bertrand competition, the production level of incumbent D_I is always zero and it does not depend on the degree of entrant D_E 's efficiency. By contrast, under Cournot competition, the production level of incumbent D_I is positive, and more importantly, an improvement of entrant D_E 's efficiency gradually reduces the production level of incumbent D_I that demands a large amount of input. This additional effect leads to further reduction of demand for input and, thus, increases the benefit of exclusion.

5 Discussion

This section briefly discusses the wholesale pricing of the input and the efficiency of downstream firms. 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. In Section 5.3, we discuss the efficiency measure of downstream firms.

5.1 Price discrimination

Thus far, we assumed that supplier U charges downstream firms a uniform price w^r . We briefly discuss how the results in Section 3 change if supplier U is able to discriminate on price when entrant D_E enters the downstream market. Then, if supplier U chooses input

prices w_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 and kw_E^r , 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 1.¹⁵

Consider the case where supplier U 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 per unit cost. In equilibrium, supplier U optimally chooses a pair of input prices (w_I^r, w_E^r) such that $w_I^r = kw_E^r$ and it earns

$$\pi^r = \max_{w_I^r} (w_I^r - kc)Q(w_I^r) = \pi^*(kc). \quad (21)$$

In contrast, downstream firms earn zero profits. The result here implies that if supplier U can discriminate on price, then it can jointly maximize profits with entrant D_E and earn all profits even under linear pricing.¹⁶ By comparing such profits with the joint profit with entrant D_E when supplier U accepts the exclusive supply offer (11), it is easy to see that condition (7) never holds, and thus, exclusion becomes impossible.

Proposition 3. *Suppose that the downstream firms are undifferentiated Bertrand competitors. Suppose also that entrant D_E always enters the market if the exclusive supply contract is rejected in Stage 1. If supplier U 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 can discriminate on price, it can extract profits of entrant D_E by setting $w_E^r = w_I^r/k$. In addition, supplier U can control the final product price by choosing input price $w_I^r = kw_E^r = p^*(kc)$. Therefore, supplier U can jointly

¹⁵This assumption is significant because the gross profit of entrant D_E after entry is zero in this model. Anticipating the subgame outcome after Stage 2, entrant D_E does not enter the market if its sunk entry fee is not compensated by supplier U . The assumption in this section implies that U pays a side payment to entrant D_E to compensate the entry fee.

¹⁶When downstream firms compete in quantity, joint profit maximization is impossible and these firms earn positive profits. The result in this section is qualitatively similar to that in which they compete in quantity.

maximize profits with entrant D_E , when it rejects the exclusive supply offer and does not engage in exclusive supply agreements.

Proposition 3 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 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 study 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). In the context of licensing agreements, licenses are often subject to fair, reasonable, and non-discriminatory (FRAND) commitments, which often require that every licensee be able to choose from the same royalty schedule (Gilbert, 2011). Layne-Farrar and Lerner (2011, p.296) mention that licensees pay the patent pool administrator either a percentage of their net sales revenue from selling the licensed product or a flat fee per unit sold. Gilbert (2011) also mentions the real-world examples of licensing terms that are subject to FRAND commitments and linear pricing contracts.¹⁷ Furthermore, linear pricing 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). Even in the situation of franchise contracts, franchisors face several problems in using franchise fees (fixed payments) as their means of compensation: for instance, wealth constraints of franchisees and franchisor opportunism

¹⁷Following those real-world observations, Tarantino (2012) considers standard setting organizations' decisions on licensing policy with linear pricing and the standard's technological specifications.

with a lump-sum fee (Blair and Lafontaine, 2005).¹⁸ Therefore, we believe that this study provides a useful policy implication in vertical restraints.

5.3 Efficiency measure

We have assumed that entrant D_E is more efficient than incumbent D_I in terms of a transformational technology of an input produced by the upstream supplier U ; that is, entrant D_E demands a smaller quantity of inputs from supplier U to produce one unit of final product. However, as commonly used in existing literature, we can consider the following efficiency measure to evaluate the efficiency of downstream firms: entrant D_E is more efficient than incumbent D_I in terms of its per unit production cost for several inputs, such as labor, which are not produced by supplier U . For example, suppose that downstream firms produce final products using input A that is exclusively supplied by an upstream supplier U_A at price w_A and input B supplied by competitive sectors at price $c_B \geq 0$. Then, we can assume that incumbent D_I produces a unit of final product using one unit of input A and one unit of input B but entrant D_E produces a unit of final product using one unit of input A and $0 < m < 1$ unit of input B :

$$w_I = w_A + c_B, \quad w_E = w_A + mc_B.$$

Under this efficiency measure, we can show that incumbent D_I cannot deter socially efficient entry by using an exclusive supply contract (proof of this result is available upon request). That is, the difference in measures to evaluate the downstream firms' efficiency turns out to be crucial.

¹⁸As also documented in Iyer and Villas-Boas (2003, p.81), in practice, both the magnitude and incidence of two-part tariffs may be insignificant. Milliou, Petrakis, and Vettas (2009) provide a theoretical reason for employing linear pricing contracts. Inderst and Valletti (2009) also explain real-world examples in which linear pricing contracts are employed.

6 Concluding Remarks

This study 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 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 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 if the entrant's efficiency is at an intermediate level.

This study 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. It may be possible to measure downstream firms' efficiency by checking the defective rate in relationships between an input supplier and final good producer and the inventory rate in relationships between a final good producer and retailers. In addition, our exclusion outcomes arise when upstream firms employ simple linear pricing contracts. This result provides two implications. First, exclusive supply agreements are more likely to be observed in industries where linear pricing contracts are employed. Linear pricing contracts are commonly employed in manufacturing, gasoline, and shipping industries and are observed for licensing agreements subject to FRAND commitments. When the presented model is applied to exclusive supply agreements in these industries, antitrust agencies should be careful in measuring

downstream firms' efficiency. Second, a ban on input price discrimination makes exclusion possible because such a ban works as an enforcement on upstream firms to employ simple linear pricing contracts.

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 under quantity competition 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

A.1: Proof of Results under General Demand

A.1.1 Proof of Lemma 3

We 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 replace $w^r(k)$ with $w(k)$, which satisfies (see the last paragraph before Lemma 3)

$$p^*(kw(k)) = w(k). \quad (22)$$

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

$$\begin{aligned} \text{Case (i)} \quad & \max_w (w - c)kQ(w) \quad s.t. \quad w \in [c, w(k)], \\ \text{Case (ii)} \quad & \max_w (w - c)kQ(p^*(kw)) \quad s.t. \quad w \in [w(k), \infty). \end{aligned}$$

The first-order conditions are given as

$$\text{Case (i)} \quad H^{(i)}(w) \equiv Q(w) + (w - c)Q'(w),$$

$$\text{Case (ii)} \quad H^{(ii)}(w) \equiv Q(p^*(kw)) + (w - c)kQ'(p^*(kw))p^{*'}(kw).$$

Note that each maximization problem has a unique interior solution on the domain $[c, \infty)$. However, there exists a possibility of a corner solution where the problem in Case (i) has an interior solution on the domain $[w(k), \infty)$ and the problem in Case (ii) has an interior solution on the domain $[c, w(k)]$. In such cases, supplier U 's profit is maximized at the corner, $w = w(k)$. 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 the 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,

$$H^{(i)}(w(k)) = Q(w(k)) + (w(k) - c)Q'(w(k)) > 0. \quad (23)$$

By using equation (22), $H^{(ii)}(w(k))$ can be rewritten as

$$H^{(ii)}(w(k)) = Q(w(k)) + (w(k) - c)kQ'(w(k))p^{*'}(kw(k)). \quad (24)$$

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

$$Q(p^*(z)) + (p^*(z) - z)Q'(p^*(z)) = 0.$$

The total differential of this equation leads to

$$p^{*'}(z) = \frac{Q'(p^*(z))}{2Q'(p^*(z)) + (p^*(z) - z)Q''(p^*(z))}. \quad (25)$$

By using equations (22), (23), (24), and (25), we have the following relationship:

$$\begin{aligned} H^{(ii)}(w(k)) &> H^{(ii)}(w(k)) - H^{(i)}(w(k)) \\ &= -\frac{(w(k) - c)Q'(w(k))\{2Q'(p^*) + (p^* - kw(k))Q''(p^*) - kQ'(p^*)\}}{2Q'(p^*) + (p^* - kw(k))Q''(p^*)} \\ &= -\frac{(w(k) - c)Q'(w(k))\{kQ'(p^*) + (1 - k)[2Q'(p^*) + p^*Q''(p^*)]\}}{2Q'(p^*) + (p^* - kw(k))Q''(p^*)} > 0, \end{aligned} \quad (26)$$

where $p^* \equiv p^*(kw(k)) = w(k)$. The last inequality holds because of $Q'(p) < 0$ and Assumption 1.

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 $(w(k), \infty)$ if in Case (i), the interior solution does not exist on the domain $[c, w(k)]$ and the corner solution appears; that is, we always have $w^{r(ii)} \in (w(k), \infty)$ if $w^{r(i)} = w(k)$. This also implies that at least one interior solution exists and that there are three possibilities concerning the optimal input price for supplier U :

1. An interior solution exists only on the domain $(c, w(k))$ in Case (i).
2. An interior solution exists only on the domain $(w(k), \infty)$ in Case (ii).
3. Interior solutions exist on the domains $(c, w(k))$ in Case (i) and $(w(k), \infty)$ in Case (ii).

In the first and the second cases, we have 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.

Q.E.D.

A.1.2 Proof of Lemma 4

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

Q.E.D.

A.1.3 Proof of Proposition 3

We first show that input prices that satisfy $w_I^r < kw_E^r$ cannot be an equilibrium. Suppose, in negation, that supplier U optimally chooses $w_I^r = v_I$ and $w_E^r = v_E$ such that $w_I^r < kw_E^r$, which

allows D_I to supply its product and to choose the price at $p_I^r = kw_E^r$. Then, supplier U earns

$$\pi^r = (w_I^r - c)Q(kw_E^r) = (v_I - c)Q(kv_E). \quad (27)$$

However, if supplier U instead chooses $w_I^r = kv_E$ and $w_E^r = v_I/k$, which satisfies $w_I^r > kw_E^r$ (that is, $kv_E > v_I$), entrant D_E supplies its product and chooses the price at $p_E^r = w_I^r$. Under this input pricing, supplier U earns

$$\pi^r = (w_E^r - c)kQ(w_I^r) = (v_I - kc)Q(kv_E).$$

This is larger than (27) because $k < 1$. This is a contradiction.

Second, we also show that we do not have $w_I^r > kw_E^r$ in the equilibrium. Suppose, in negation, that supplier U optimally chooses $w_I^r > kw_E^r$. Then, supplier U earns

$$\pi^r = (w_E^r - c)kQ(w_I^r) = (kw_E^r - kc)Q(w_I^r) < (w_I^r - kc)Q(w_I^r) = \pi^*(kc).$$

That is, by setting kw_E^r at w_I^r , supplier U can increase its profit. This is a contradiction. Therefore, the optimal input prices of supplier U satisfy $w_I^r = kw_E^r$ and its profit is $\pi^r = \pi^*(kc)$ in (21). This is higher than the sum of profits in (11). Therefore, Proposition 3 holds.

Q.E.D.

A.2 Proof of Results under Linear Demand

A.2.1 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 A.2.1.1, we consider the case where an exclusive offer is accepted by the upstream supplier. Then, in A.2.1.2, we consider the case where the exclusive offer is rejected by this supplier.

A.2.1.1 When the exclusive offer is accepted in Stage 1

The equilibrium demand level for the input becomes

$$q^a = Q_I^a = \frac{a - c}{4b}.$$

Before compensation through x , the profits of supplier U and incumbent D_I are given as

$$\pi^a = \frac{(a-c)^2}{8b}, \quad \Pi_I^a = \frac{(a-c)^2}{16b}.$$

A.2.1.2 When the exclusive offer is rejected in Stage 1

As we have seen in Section 3, there are two types of equilibria in the subgame after the exclusive offer is rejected in Stage 1. We first solve each case on the full domain $w^r \in [c, \infty)$.

Consider Case (i). The profits of supplier U and incumbent D_I are given as

$$\pi^{r(i)} = k \frac{(a-c)^2}{4b}, \quad \Pi_I^{r(i)} = 0.$$

Next, we consider Case (ii). Given w , entrant D_E chooses the following price.

$$p^*(w) = \frac{a + kw}{2}.$$

The equilibrium input price and price of final product are given as

$$w^{r(ii)} = \frac{a - kc}{2k}, \quad p_E^{r(ii)} = \frac{3a + kc}{4}.$$

the profits of supplier U and incumbent D_I are given as

$$\pi^{r(ii)} = \frac{(a - kc)^2}{8b}, \quad \Pi_I^{r(ii)} = 0.$$

We now determine the optimal input price for supplier U . For $0 < k \leq 1/2$, we always have $\pi^{r(i)} < \pi_A^{r(ii)}$. In contrast, for $1/2 < k < 1$, we have $\pi^{r(i)} < \pi^{r(ii)}$ if $c > \dot{C}(k)$, where

$$\dot{C}(k) = \frac{a(k - \sqrt{2k(1-k)})}{k(2-k)},$$

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

Finally, we examine whether input prices in each equilibrium satisfy the definition of each case. We first check Case (i). For $0 < k < 1$, we have $p^*(w^{r(i)}) > w^{r(i)}$ if $c < \check{C}(k)$, where

$$\check{C}(k) = \frac{ka}{2-k},$$

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

$$\check{C}(k) - \acute{C}(k) = \frac{a(\sqrt{2k} - k)(1 - k)}{k(2 - k)} > 0,$$

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

$$\grave{C}(k) = \frac{a(3k - 2)}{k(2 - k)},$$

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

$$\acute{C}(k) - \grave{C}(k) = \frac{a(2 - \sqrt{2k})(1 - k)}{k(2 - k)} > 0,$$

for all $2/3 < k < 1$, whenever we have $\pi^{r(i)} < \pi^{r(ii)}$, the equilibrium input price in Case (ii) satisfies $p_E^{r(ii)} < w^{r(ii)}$. 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 $c \leq \acute{C}(k)$ ($c > \acute{C}(k)$).

A.2.2 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 $0 \leq c < \hat{C}(k)$.

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. 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

See Appendix A.2.1.1.

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

When supplier U rejects the exclusive supply offer, entrant D_E enters the downstream market and supplier U deals with incumbent D_I and entrant D_E . Given w , the quantities supplied by the downstream firms are given as

$$q_I^r(w) = \begin{cases} \frac{a - (2 - k)w}{3b}, & \text{if } w \leq \frac{a}{2 - k}, \\ 0, & \text{if } w \geq \frac{a}{2 - k}, \end{cases}$$

$$q_E^r(w) = \begin{cases} \frac{a + (1 - 2k)w}{3b}, & \text{if } w \leq \frac{a}{2 - k}, \\ \frac{a - kw}{2b}, & \text{if } w \geq \frac{a}{2 - k}, \end{cases}$$

Anticipating the outcome, supplier U sets its w to maximize its profit.

$$\max_w (w - c)(q_I(w) + kq_E(w)).$$

First, for $w \leq a/(2 - k)$, we derive the “local” optimal input price. The maximization problem is given as

$$\max_w (w - c) \left(\frac{a - (2 - k)w}{3b} + k \frac{a + (1 - 2k)w}{3b} \right) \quad s.t. \quad w \leq \frac{a}{2 - k}.$$

This leads to

$$w^r = \frac{(1 + k)a + 2(1 - k + k^2)c}{4(1 - k + k^2)}.$$

This is an interior solution if and only if

$$c \leq \frac{2 - 5k + 5k^2}{2(2 - 3k + 3k^2 - k^3)}.$$

The profits of supplier U and incumbent D_I are given as

$$\pi^r = \frac{(a(1 + k) - 2c(k^2 - k + 1))^2}{24b(k^2 - k + 1)}, \quad \Pi_I^r = \frac{(a(5k^2 - 5k + 2) - 2c(2 - k)(k^2 - k + 1))^2}{144b(k^2 - k + 1)}.$$

Second, for $w \geq a/(2 - k)$, we derive the “local” optimal input price. The maximization problem is given as

$$\max_w (w - c)k \frac{a - kw}{2b} \quad s.t. \quad w \geq \frac{a}{2 - k}.$$

This leads to

$$w^r = \frac{a + kc}{2k}.$$

This is an interior solution if and only if

$$c \geq \frac{3k - 2}{k(2 - k)}.$$

The profits of supplier U and incumbent D_I are given as

$$\pi^r = \frac{(a - kc)^2}{8b}, \quad \Pi_I^r = 0.$$

For any $c \in [0, a)$ such that

$$\frac{3k - 2}{k(2 - k)} \leq c \leq \frac{2 - 5k + 5k^2}{2(2 - 3k + 3k^2 - k^3)},$$

the two local optimal input prices exist. We now determine the one that is better for supplier U . The first input price leads to higher profits for U if and only if $c < \hat{C}(k)$ (see (20)). Therefore, if $c < \hat{C}(k)$, the optimal input price is the first w^r , and then, both incumbent D_I and entrant D_E are active. Otherwise, it is the second w^r , and then, only entrant D_E is active.

B.2 Proofs of Results

Proof of Proposition 2

We explore whether an exclusion equilibrium exists by examining whether the inequality in (7) holds. Substituting the result in the previous subsection into the inequality in (7), we have the condition, $0 < c < \bar{C}(k)$ (see (19)), in Proposition 2. Therefore, an exclusion equilibrium exists for $0 \leq c < \bar{C}(k)$.

Q.E.D.

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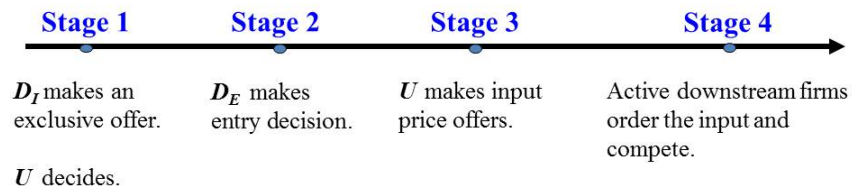


Figure 1: Time line

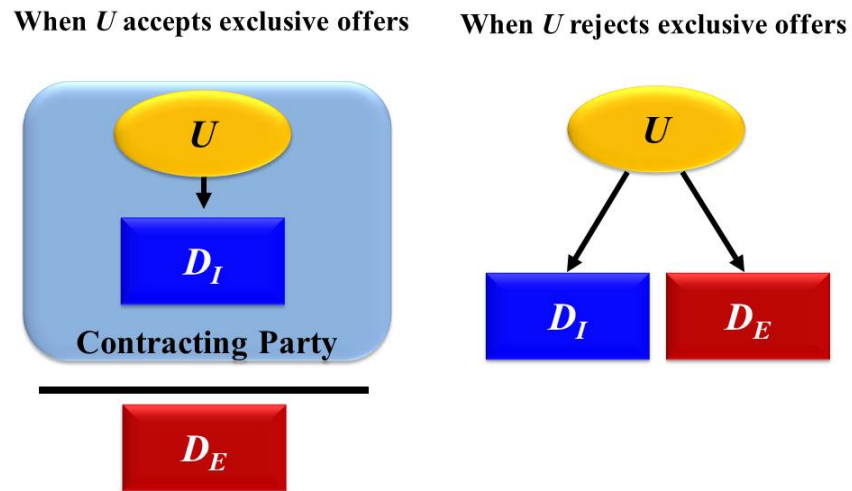


Figure 2: Wholesale price offers in Stage 3

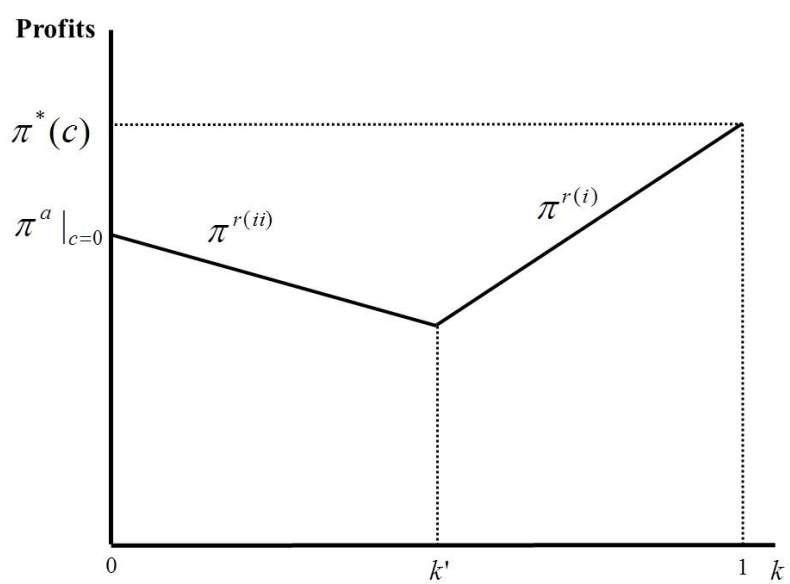


Figure 3: Properties of $\max \{\pi^{r(i)}, \pi^{r(ii)}\}$

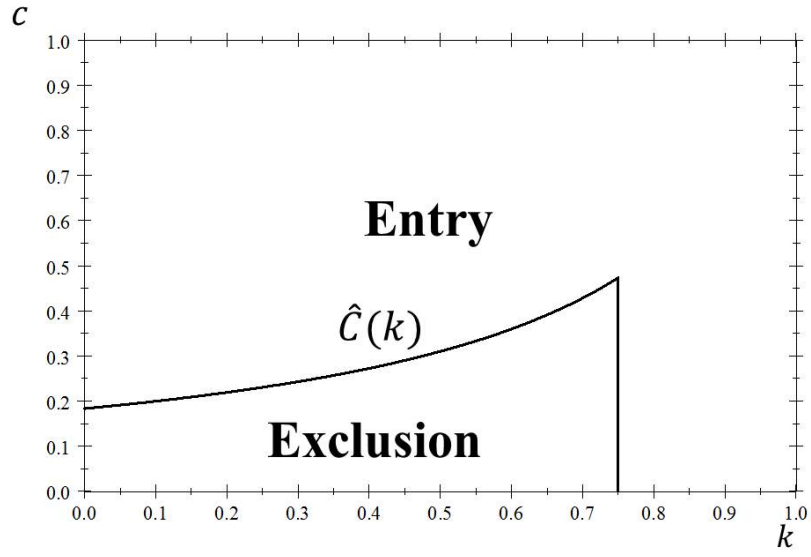


Figure 4: Results of Proposition 1 under linear demand ($a = 1$)

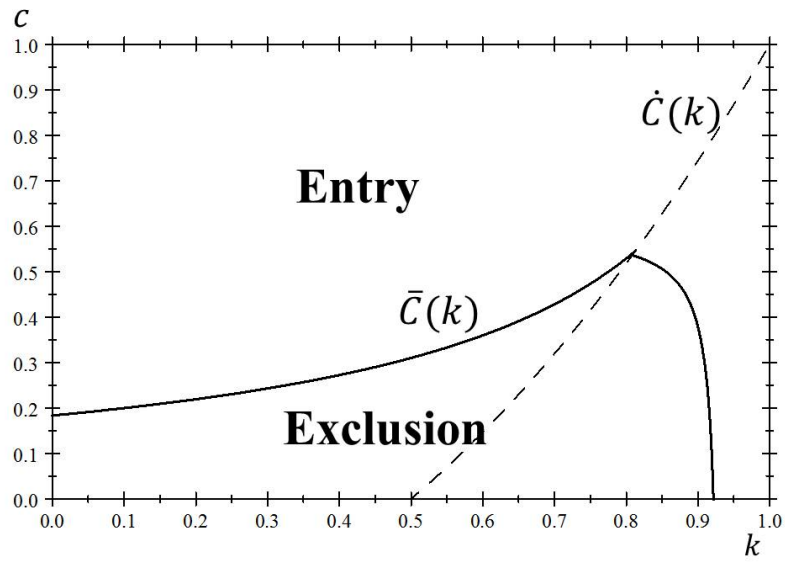


Figure 5: Results of Proposition 2 ($a = 1$)