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HOW DOES DOWNSTREAM FIRMS' EFFICIENCY AFFECT EXCLUSIVE SUPPLY AGREEMENTS?

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Abstract

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

JEL classifications code: L12, L41, L42, C72.
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, such contracts can deter efficient entrants. Thus, such contracts seem to be anticompetitive—a view opposed by the Chicago School. For instance, by constructing a model with 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.[3] In a rebuttal of the Chicago School argument, post-Chicago economists indicate specific circumstances under which anticompetitive exclusive dealings occur.[4] By extending the Chicago School argument's single-buyer model to a multiple-buyer model, these studies introduce scale economies, wherein the entrant needs a certain number of buyers to cover fixed costs (Rasmusen, Ramseyer, and Wiley, 1991; Segal and Whinston, 2000a) and competition between the buyers (Simpson and Wickelgren, 2007; Abito and Wright, 2008).

Although these studies investigate cases in which an upstream incumbent makes exclusive offers to downstream firms, in real business situations, downstream firms offer exclusive supply contracts to upstream firms. An example of the relationship between an input supplier and final good producer is when the U.S. Federal Trade Commission (FTC) stopped a large-scale pharmaceutical company from enforcing 10-year exclusive supply agreements for an essential ingredient.[5] The FTC also exemplified the relationship between a final goods producer and retailers when it stopped an established toy retailer from preventing toy manufacturers from selling to warehouse clubs.[6] More recently, the Japan Fair

[1]See, for example, Rey and Tirole (1986), Rey and Vergé (2010), and Asker and Bar-Isaac (2014). See also Rey and Tirole (2007) and Rey and Vergé (2008) for surveys of vertical restraints.

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

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

[4]In an early contribution, Aghion and Bolton (1987) propose a model in which exclusion does not always occur, although when it does, it is anticompetitive. See also Bernheim and Whinston (1998), who explore market circumstances under which an exclusive contract excludes 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.shtm).

[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

Trade Commission stopped an online gaming company from preventing mobile game developers from providing their games through a rival online gaming company.[7] Thus, 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 constructs a model of anticompetitive exclusive supply contracts by inverting the vertical relationship in the Chicago School argument. The model comprises an upstream supplier and downstream incumbent. However, a new downstream firm, which needs input produced by the upstream supplier, arrives as an entrant. The incumbent then offers an exclusive supply contract to the upstream supplier, as in the standard models for anticompetitive exclusive dealing. If the contract is achieved, then the new entrant cannot enter the market.

In 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 the 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. The efficiency measure in this study, however, cannot be neglected because economists have reported significant differences in producer productivity within industries. For example, Syverson (2004) finds large productivity differences even within narrowly defined industries in the U.S. manufacturing sector. More specifically, using the same measured inputs, he finds that the output of the plant at the 90th percentile of productivity distribution is almost twice that of the plant at the 10th percentile.[8] Importantly, the present model differs in not only relation to a market structure where exclusion occurs, but also 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, because they focus on entry deterrence in the upstream market.

(https://bulk.resource.org/courts.gov/c/F2/799/799.F2d.905.85-2362.html). See Comanor and Rey (2000) for detailed discussions.

[7] See *Cease and Desist Order against DeNA Co., Ltd* (http://www.jftc.go.jp/en/pressreleases/yearly-2011/jun/individual-000427.html.).

[8] See Syverson (2011) for details on a related survey.

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 upstream supplier can sign exclusive supply contracts to deter a socially efficient entry even in the framework of the Chicago School argument, where a single seller, buyer, and entrant exist. More precisely, when the entrant and incumbent have similar efficiency levels, exclusion never occurs; however, as the entrant's efficiency increases, exclusion can occur. To understand our results, consider the impact of a 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 input produced by the upstream supplier and, consequently, its profit. Thus, the demand expansion effect of a socially efficient entry makes anticompetitive exclusive dealings difficult. However, as the entrant becomes increasingly efficient, it demands a smaller quantity of input produced by the upstream supplier. In addition, such an entry decreases the market share of the downstream incumbent, which demands a larger quantity of input produced by the upstream supplier.[9] Therefore, as the entrant becomes efficient, its entry does not lead to a significant increase in the demand for input produced by the upstream supplier; that is, the upstream supplier does not welcome the highly efficient entrant. This induces the upstream supplier to engage in anticompetitive exclusive dealings to deter a socially efficient entry into the downstream market.

This study also shows that the relationship 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 increases further, the price of the 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 entrant has a significantly high level of efficiency.

In addition, this study shows that exclusion is more likely to occur if the upstream supplier's

[9] If the downstream firms compete in quantity, an improvement in the entrant's efficiency gradually diminishes the downstream incumbent's market share. If the downstream firms compete in price and their goods are perfect substitutes, the downstream incumbent's market share will be zero, that is, there is a drastic depression in its market share.

efficiency is high. The existence of an entrant with more efficient technology than the incumbent not only decreases demand for input as well as the upstream supplier's profits but also reduces the production cost of the upstream supplier, which improves the 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.

Few studies do address anticompetitive exclusive supply contracts, notably, Comanor and Rey (2000) consider a market in which a single upstream supplier, a single downstream incumbent with external suppliers, and a single downstream entrant exist.[10] They point out that the downstream incumbent's outside option to buy inputs is a key factor in the emergence of anticompetitive exclusive supply agreements when each downstream firm offers a purchase (wholesale) price and then the upstream supplier chooses the higher one. Because the outside option diminishes the downstream incumbent's incentive to offer a higher purchase price, the efficient downstream entrant does not offer a higher purchase price either. Therefore, the upstream supplier cannot earn higher profits even when a socially efficient downstream entry occurs, which induces the upstream supplier to engage in anticompetitive exclusive dealings. By contrast, the present study does not consider the downstream incumbent's outside option but explores how a difference in downstream firms' technology affects anticompetitive exclusive supply agreements.

This study is also related to the literature on anticompetitive exclusive dealings to deter upstream entrants.[11] Fumagalli and Motta (2006) propose an extension of Rasmusen, Ramseyer, and Wiley (1991) and Segal and Whinston's (2000a) model wherein buyers are competing firms.[12] They show

[10]Recently, by inverting the vertical relationship analyzed by Simpson and Wickelgren (2007) and Abito and Wright (2008), Oki and Yanagawa (2011) show that upstream competition induces upstream suppliers to sign exclusive supply contracts, forcing upstream suppliers into always earn low profits.

[11]Certain studies examine pro-competitive 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 dealings in encouraging non-contractible investments. Chen and Sappington (2011) study the impact of exclusive contracts on an industry's R&D and welfare. Fumagalli, Motta, and Rønde (2012) examine the interaction between pro-competitive and anticompetitive effects and show that the investment promotion effect of exclusive dealing may facilitate anticompetitive exclusive dealing. In addition, Argenton and Willems (2012) analyze the trade-off between the positive (risk sharing) and negative (exclusion) effect of exclusive contracts. Calzolari and Denicolò (2013) explore the pro-competitive effects of exclusive contracts in an adverse selection model, in which differentiated firms compete in non-linear prices. Another motivation to consider exclusive dealing is to solve the commitment problem, as suggested by Hart and Tirole (1990), which arises when a single upstream firm sells to multiple retailers with two-part tariffs under unobservable contracts. See also O'Brien and Shaffer (1992), McAfee and Schwartz (1994), and Rey and Vergé (2004).

[12]Fumagalli and Motta (2008) also show that exclusion with scale economies arises because of coordination failure among

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.[13] Wright (2008) and Argenton (2010) explore the extended models of exclusion with downstream competition where the incumbent and a potential entrant, respectively, produce a horizontally and vertically differentiated product. Both studies show that the resulting exclusive dealing is anticompetitive.[14] Although these studies have similar motivations, none of them discusses the possibility of exclusion in the downstream market.

The remainder of this paper is organized as follows. Section 2 constructs the basic environment of the model. Section 3 analyzes the case where downstream firms compete in price. Section 4 provides a discussion and Section 5 offers concluding remarks. In Appendix A, we present the proofs of results under price competition, and in Appendix B, we analyze the case where downstream firms compete in quantity. Appendix C is an analysis of the case where industry profits are allocated by bargaining.

2 Preliminaries

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

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.

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

[14] Kitamura (2010, 2011) also explores the extended model—first, in the presence of multiple entrants, and next, with financial constraints. Johnson (2012) extends the models in the presence of adverse selection. Kitamura, Sato, and Arai (2014) explore the model when the incumbent can establish a direct retailer. DeGraba (2013) extends the models where a small rival that is more efficient at serving some portion of the market can make exclusive offers. These studies show that the resulting exclusive dealings are anticompetitive. In contrast, Gratz and Reisinger (2013) show that exclusive contracts can possibly have pro-competitive effects if downstream firms compete imperfectly and contract breaches are possible.

and retailers.

2.1 Upstream and downstream markets

The downstream market is composed of an incumbent D_I and entrant D_E. Each of them produces a unit of final product using an input exclusively produced by an upstream supplier 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 production technology. D_I produces a unit of final product using one unit of input. The transformational technology is denoted by

$$Q_I = q_I,$$

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

$$c_I = w. \tag{1}$$

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

$$Q_E = q_E/k,$$

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

$$c_E = kw. \tag{2}$$

Equation (2) implies that D_E becomes efficient (that is, the per unit cost of D_E decreases) as k decreases. We assume that $0 < k < 1$. Comparing (1) with (2) clearly shows that D_E is more efficient than D_I in terms of per unit production cost.

There are two interpretations of this assumption. First, between an input supplier and final good producers, entrant producer D_E has the efficient technology that allows it to reduce the use of input or defective products. Second, between a final good producer and retailers, entrant retailer D_E is better at supply-chain management than the incumbent, because of 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 those in previous studies on anticompetitive exclusive dealing. Those previous studies do not focus on differences in the transformational technology of input, because they explore the existence of entry deterrence in the upstream market. If competitive sectors supply inputs for the upstream firms, the difference in the transformational technology of inputs causes a qualitatively similar difference in their constant marginal costs, the latter of which is usually assumed in the previous studies, and more importantly, the possibility of exclusion does not depend on these efficiency measures. In contrast, this study shows that if we focus on the existence of entry deterrence in the downstream market, the difference in the transformational technology of input produced by the upstream supplier is an important efficiency measure for downstream firms.[15]

2.2 Timing of the game

The timing of the game is as follows (Figure 1). The model consists of four stages. In Stage 1, D_I offers an exclusive supply contract to U. This contract involves some fixed compensation $x \geq 0$. U decides whether to accept this offer. In Stage 2, D_E decides whether to enter the downstream market. We assume that the fixed cost of entry $f(> 0)$ is sufficiently small, such that if D_E is active, it could earn positive profits. In Stage 3, U offers a linear wholesale price of input, w, to the active downstream firm(s). There are two cases (see Figure 2). If U accepts the exclusive supply offer in Stage 1, then it offers input price w^a only to D_I; the superscript a indicates that U has accepted the offer. In contrast, if U rejects the exclusive supply offer in Stage 1, then it offers input price w^r to all active downstream firms; the superscript r indicates that U has rejected the offer. We assume that U cannot offer different wholesale prices to downstream firms (In Section 4, we discuss the case where such price discrimination is possible.). In Stage 4, active downstream firms order input and compete in the final market. If an entry arises in Stage 2, then D_I and D_E compete. D_I's profit when U accepts (rejects) the exclusive offer is denoted by π_I^a (π_I^r) and U's profit when it accepts (rejects) the exclusive offer is denoted by π_U^a (π_U^r).

[15] In Section 4.3, we briefly provide the discussion on the efficiency measure of downstream firms.

2.3 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 an exclusion equilibrium, the equilibrium transfer x^* must satisfy the following two conditions.

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

$$\pi_I^a - x \geq \pi_I^r. \tag{3}$$

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

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

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

$$\pi_I^a + \pi_U^a \geq \pi_I^r + \pi_U^r. \tag{5}$$

Condition (5) implies that for the existence of anticompetitive exclusive supply contracts, we must examine whether exclusive supply agreements increase the joint profits of D_I and U. Therefore, the existence of exclusion equilibria does not depend on who makes the offer; in other words, the results do not change even if we allow U to make the exclusive supply offer.

3 Price Competition

This section considers 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 a general demand function $Q(p)$ is continuous and $Q'(p) < 0$. Further, we assume that demand from D_i, where $i \in \{I, E\}$, depends on not only its price but also that of D_{-i}'s price. 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 $Q(p_i)$.[16] For

[16]This assumption avoids open-set problems when defining equilibria. See, for example, Abito and Wright (2008).

notational convenience, we define $p^*(z)$ and $\Pi^*(z)$ as follows:

$$p^*(z) \equiv \arg\max_p (p - z)Q(p), \tag{6}$$

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

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

Assumption 1. *The following inequality is satisfied:*

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

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

$$w^a = \arg\max_w (w - c)Q(p^*(w)). \tag{7}$$

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 D_I and U; that is, the double marginalization problem occurs.

$$\pi_I^a + \pi_U^a = (p^*(w^a) - c)Q(p^*(w^a)) < \Pi^*(c). \tag{8}$$

Although the entry deterrence allows D_I to earn higher operating profits, D_I and U cannot maximize their joint profits owing to the double marginalization problem.

We next consider the case where U rejects the exclusive supply offer in Stage 1. In this case, D_E enters the downstream market in Stage 2. In Stage 4, given the input price w^r, the downstream firms compete in price. 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) D_I offers $p_I^{r(i)} = w^r$ and D_E offers $p_E^{r(i)} = w^r$ if $p^*(kw^r) \geq w^r$.

Case (ii) D_I offers $p_I^{r(ii)} = w^r$ and 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 D_I binds the pricing of 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 D_I does not bind the pricing of D_E, which leads to $p_E^{r(ii)} = p^*(kw^r)$.

By anticipating this pricing in Stage 4, U optimally chooses its input price in Stage 3. Note that for each case, we have a unique interior solution; that is, we have $w^{r(i)} \in [c, \infty)$ and $w^{r(ii)} \in [c, \infty)$. However, each interior solution must satisfy the constraints ($w^{r(i)} \in [c, p^*(w^r(k))]$ and $w^{r(ii)} \in [p^*(w^r(k)), \infty)$), 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). In the rest of this section, we first characterize the properties of each interior solution in 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 U's profit in Lemma 4.

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

$$q_E^{r(i)} = kQ(p_E^{r(i)}) = kQ(w^r). \tag{9}$$

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

$$\pi_U^{r(i)} = \max_{w^r} \ k(w^r - c)Q(w^r) = k\Pi^*(c). \tag{10}$$

Note that when $k = 1$, $\pi_U^{r(i)} = \Pi^*(c)$, which implies that D_E's entry allows U to earn profits equivalent to the maximized value of the joint profits of U and D_I. From equations (8) and (10), we identify the following properties.

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

1. *$\pi_U^{r(i)}$ is strictly increasing in k but decreasing in c.*
2. *As $k \to 1$, $\pi_U^{r(i)} \to \Pi^*(c)$, which is strictly larger than $\pi_I^a + \pi_U^a$.*

3. *As* $k \to 0$, $\pi_U^{r(i)} \to 0$.

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

$$\pi_U^{r(ii)} = \max_{w^r}(w^r - c)kQ(p^*(kw^r)) = \max_{w}\{wQ(p^*(w)) - kcQ(p^*(w))\}. \tag{11}$$

From equations (7) and (11), we identify the following properties.

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

1. $\pi_U^{r(ii)}$ *is strictly decreasing in* k *and* c.

2. *As* $k \to 1$, $\pi_U^{r(ii)} \to \pi_U^a$.

3. *For any* $c \geq 0$, *as* $k \to 0$, $\pi_U^{r(ii)} \to \pi_U^a|_{c=0}$.

4. *For* $c = 0$, $\pi_U^{r(ii)} = \pi_U^a|_{c=0}$,

where $\pi_U^a|_{c=0}$ *is* U*'s profit level under the standard double marginalization problem when* $c = 0$ *(see equation (7)).*

We now characterize these two equilibria on two domains, $[c, w^r(k)]$ and $[w^r(k), \infty)$. 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,* $w^{r(i)} \in (c, w^r(k))$ *or* $w^{r(ii)} \in (w^r(k), \infty)$.

Because we have $\pi_U^{r(i)} = \pi_U^{r(ii)}$ for $w^{r(i)} = w^{r(ii)} = w^r(k)$, we can conclude that one of the above-mentioned interior solutions becomes U's optimal solution in equilibrium. Therefore, exclusion is possible regardless of equilibrium type if we have

$$\pi_I^a + \pi_U^a > \max\{\pi_U^{r(i)}, \pi_U^{r(ii)}\}. \tag{12}$$

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

Lemma 4. $\max\{\pi_U^{r(i)}, \pi_U^{r(ii)}\}$ *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*

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

Figure 3 summarizes the property of $\max\{\pi_U^{r(i)}, \pi_U^{r(ii)}\}$. Note that the equilibrium outcome when the exclusive supply offer is accepted does not depend on k (see equation (8)). Therefore, exclusion is possible if condition (12) 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.*

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

$$k^* \equiv \frac{\pi_I^a + \pi_U^a}{\Pi^*(c)}.$$

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

   (a) When U is sufficiently efficient, $0 \le c < \tilde{c}$*, exclusion is possible for* $0 < k < k^*$*, where* $\tilde{c}$ *is the threshold value such that* $\pi_U^a\big|_{c=0} = \pi_I^a + \pi_U^a$.

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

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

Remark 1. *Under linear demand, the exclusion of the highly efficient* D_E *(*$k < 3/4$*) occurs if U is sufficiently efficient (*$c < 0.18a$ *is sufficient). More precisely,*

1. *for* $3/4 \le k < 1$*, entry is a unique equilibrium outcome, and*

2. *for* $0 < k < 3/4$*, exclusion is a unique equilibrium outcome if* U *is sufficiently efficient, that is,* $0 \leq c < \hat{C}(k)$*, where*

$$\hat{C}(k) = \frac{a(\sqrt{6} - 2)}{\sqrt{6} - 2k}. \tag{13}$$

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

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 $\tilde{c} = (3 - \sqrt{6})a/3 \simeq 0.1835a$. In Appendix B, we explore the case where downstream firms compete in quantity and show that exclusion may arise even when $k > 3/4$. Note that condition (12) is a sufficient condition. Therefore, there may exist an exclusion equilibrium even when condition (12) does not hold. Remark 1 shows such a possibility.

The result in Proposition 1 contrasts those in the literature on anticompetitive exclusive dealings. In the previous literature, as the entrant becomes efficient, firms are unlikely to engage in anticompetitive exclusive dealings. By contrast, in this study, anticompetitive exclusive dealings are likely to be observed as the entrant becomes efficient. In other words, an exclusive contract works like the Luddites.[17]

The result in Proposition 1 is derived from the negative relationship between D_E's efficiency and input demand. Equation (9) implies that the demand for input decreases as D_E becomes efficient (or as k decreases) in Case (i). The socially efficient entry of D_E generates two effects. First, D_E's entry generates downstream competition and increases the production level of final goods. This expands the demand for input and increases U's profit. Second, contrarily, D_E's entry decreases D_I's market share but increases its own market share—note that D_E demands a smaller amount of input unlike D_I. This reduces the total input demand, and hence, U's profit. Therefore, the entry of the highly efficient D_E increases the profit of U only slightly. This allows D_I to profitably compensate the upstream supplier's profit when such an entry occurs by using its monopoly profits under exclusive dealing.

However, Figure 4 also shows that the relationship between the likelihood of exclusion and D_E's efficiency is non-monotonic; that is, exclusion is more (less) likely to be observed for the intermediate

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

(significantly high) level of D_E's efficiency. When D_E becomes sufficiently efficient, the equilibrium outcome under entry becomes Case (ii) and D_E can monopolize the downstream market. In Case (ii), the existence of D_I does not work as a constraint on D_E's pricing and a further improvement in D_E's efficiency decreases the price of final products, which then expands the production level of D_E and the input demand. Therefore, as equation (11) implies, for the significantly higher level of D_E's efficiency, U welcomes an improvement in D_E's efficiency. This decreases the possibility of anticompetitive exclusion.

In addition, note that Figure 4 implies that the possibility of anticompetitive exclusive dealings depends on U's efficiency: as U becomes inefficient, the possibility of anticompetitive exclusive supply agreements decreases. Equation (11) implies that in Case (ii), D_E's efficient transformational technology reduces U's production cost, which improves the latter's profit. As U becomes less efficient, the benefit of such cost reduction increases for U, which decreases the possibility of anticompetitive exclusive supply agreements.

4 Discussion

This section briefly discusses the wholesale pricing of input and efficiency of downstream firms. Section 4.1 extends the analysis by allowing price discrimination by the upstream supplier. Section 4.2 discusses two-part tariff contracts and the plausibility of employing linear wholesale pricing. Section 4.3 elaborates on the efficiency measure of downstream firms.

4.1 Price discrimination

Thus far, we assumed that U charges downstream firms a uniform price w^r. This subsection discusses how the results in Section 3 change if U is able to discriminate on price when D_E enters the downstream market. Then, if U chooses input prices w_i^r for D_i, where $i \in \{I, E\}$, the per unit costs of D_I and D_E are denoted by w_I^r and kw_E^r.

Consider the case where U rejects the exclusive supply offer in Stage 1 and D_E enters the downstream market in Stage 2. In Stage 4, given the input prices set in Stage 3, undifferentiated Bertrand competition occurs, which leads to monopolization by the downstream firm with a lower per unit cost.

In equilibrium, U optimally chooses a pair of input prices (w_I^r, w_E^r), such that $w_I^r = kw_E^r = p^*(kc)$ in Stage 3, and earns $\pi_U^r = (w_E^r - c)kQ(w_I^r) = (p^*(kc) - kc)Q(p^*(kc)) = \Pi^*(kc)$. This implies that if supplier U can discriminate on price, then it can jointly maximize profits with D_E and earn all profits even under linear pricing. In contrast, downstream firms earn zero operating profits. This result implies that price discrimination induces D_E not to cover a fixed cost $f > 0$, and D_E does not enter the downstream market in Stage 2 even when U rejects the exclusive supply offer in Stage 1. Therefore, when price discrimination is possible, there is a price commitment problem; that is, U is unable to initially commit to an input price offer that allows D_E to cover the fixed cost.[18]

Proposition 2. *Suppose that the downstream firms are undifferentiated Bertrand competitors. When U is allowed to discriminate on price, exclusion is a unique equilibrium outcome if U cannot commit to input prices before the entry decision of D_E.*

To avoid the commitment problem, naturally, U tries to commit to input prices before D_E makes its entry decision. To consider this case, we change the timing of the games as follows. In Stage 2, U makes input price offers and can commit to these prices. In Stage 3, D_E makes its entry decision. We also assume that the fixed cost of entry f is not too large such that U welcomes the entry of D_E.

Assumption 2. *The fixed cost of entry satisfies the following condition:*

$$0 < f < \Pi^*(kc) - (w^a - c)Q(p^*(w^a)). \tag{14}$$

If condition (14) does not hold, U does not induce D_E to enter the downstream market because it earns higher profits by trading with D_I. Thus, D_E does not enter the downstream market.

Note that the timing change does not affect the equilibrium outcomes for the case where U accepts the exclusive supply offer in Stage 1. However, the difference arises in the case where U rejects the exclusive supply offer in Stage 1. In Stage 2, U optimally chooses a pair of input prices (w_I^r, w_E^r), such that $w_I^r = p^*(kc)$ and $w_E^r = w_I^r/k - f/kQ(w_I^r)$, and earns

$$\pi_U^r = (w_E^r - c)kQ(w_I^r) = (p^*(kc) - kc)Q(p^*(kc)) - f = \Pi^*(kc) - f.$$

[18]When downstream firms compete in quantity, joint profit maximization is impossible and D_E earns a positive profit, which is lower than that when U employs a uniform price. The result in this section is qualitatively similar to that of the case in which they compete in quantity.

In contrast, downstream firms earn zero profits. By comparing such profits with the joint profit with D_I when U accepts the exclusive supply offer (8), it is easy to see that condition (5) holds for the sufficiently large fixed cost of entry f. For the upper bound value of f in condition (14), U is indifferent between trading D_E with fixed cost compensation and D_I without the invitation of D_E; namely, the right-hand side of condition (5) becomes $\pi_I^r + \pi_U^r = \Pi^*(kc) - f = (w^a - c)Q(p^*(w^a)) = \pi_U^a < \pi_I^a + \pi_U^a$. The last inequality holds because D_I earns a positive profit $\pi_I^a > 0$ whenever D_E does not exist. This implies that f exists, which simultaneously satisfies conditions (5) and (14).

Proposition 3. *Suppose that the downstream firms are undifferentiated Bertrand competitors. In addition, suppose that U can commit to input prices before the entry decision, such that D_E always enters the market if the exclusive supply offer is rejected. When U is allowed to discriminate on price, an exclusion equilibrium is possible if the fixed cost of entry is sufficiently large.*

1. *For $0 < f < f^*$, entry is a unique equilibrium outcome, where*

$$f^* = \Pi^*(kc) - (p^*(w^a) - c)Q(p^*(w^a)). \tag{15}$$

2. *For $f^* \leq f < \Pi^*(kc) - (w^a - c)Q(p^*(w^a))$, exclusion is a unique equilibrium outcome.*

Note that for $f = f^*$, the producer surplus in the exclusion outcome and entry outcome coincide; $\pi_U^a + \pi_I^a + \pi_E^a = \pi_U^r + \pi_I^r + \pi_E^r - f^*$. However, the consumer surplus under the entry outcome is strictly higher because the entry of D_E increases the output of final product Q by solving the double marginalization problem. Therefore, there exists the fixed cost $f(> f^*)$, under which the entry of D_E is socially efficient but deterred by anticompetitive exclusive supply contracts.

Moreover, note that the exclusion outcome in Proposition 3 can be observed for all $0 < k < 1$ and $c \geq 0$. Hence, the mechanism for exclusion is different from that in Section 3. The results here can be explained using the feature of U's outside option when it rejects the exclusive supply offer. When U invites D_E's entry, price discrimination allows U to jointly maximize profits with D_E, which apparently makes exclusion difficult. However, when U trades with D_I, instead of inviting D_E, linear pricing prevents U from not only maximizing the joint profits with D_I but also extracting all of them. Hence, even for a large fixed cost of entry, U has an incentive to invite D_E, which induces U to earn lower profits when the exclusive offer is rejected. Therefore, there is a room for D_I to profitably compensate U with the exclusive supply offer for the sufficiently large fixed cost, f.

The results here provide several implications for antitrust agencies. First, when we consider price discrimination under an exclusive supply agreement, the possibility of exclusion is sensitive to the fixed cost. Because price discrimination allows upstream firms to easily extract downstream firms' operating profits, downstream entry is less likely if an upstream supplier is unable to commit to input prices. More importantly, even when the upstream supplier can commit to input prices, anticompetitive exclusive supply agreements occur to cover a large fixed cost. Therefore, the model predicts that exclusive supply agreements are more likely to be observed in industries with large fixed costs, which supports the finding in Rasmusen, Ramseyer, and Wiley (1991), who show that anticompetitive exclusive dealing occurs if the entrant faces scale economies.

Second, the results in Proposition 3 regarding smaller fixed costs of entry and the result in Section 3 imply that for a smaller fixed cost, anticompetitive exclusive supply agreements occurs under uniform pricing and not price discrimination. This provides an important insight that the imposition of uniform pricing induces the 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 shows 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 conclude that this study shows an alternate manner in which a ban on input price discrimination harms market environments.

4.2 Two-part tariff and linear wholesale pricing

We assumed that U charges downstream firms linear pricing contracts. We briefly discuss how the results in Section 4.1 change if U is able to adopt two-part tariffs and make take-it-or-leave-it offers. Then, we briefly mention the plausibility of employing linear wholesale pricing.

Like discrimination on linear pricing, two-part tariffs allow U to jointly maximize profits with D_E and earn all profits when U rejects the exclusive offer. Therefore, a commitment problem still exists.

Proposition 4. *Suppose that the downstream firms are undifferentiated Bertrand competitors. When U adopts two-part tariffs and makes take-it-or-leave-it offers, exclusion is a unique equilibrium outcome if U cannot commit to input prices before the entry decision of D_E.*

By contrast, suppose that U can overcome the commitment problem. Then, like price discrimination on linear pricing, when U rejects the exclusive supply offer, it earns $\Pi^*(kc) - f$. However, unlike price discrimination on linear pricing, when U accepts the exclusive supply offer, it can jointly maximize profits with D_I and earn *all* of $\Pi^*(c)$, which implies that D_I earns nothing even when it trades with U; namely, condition (14) is changed to

$$0 < f < \Pi^*(kc) - \Pi^*(c). \tag{16}$$

On comparing conditions (14) and (16), it is easy to see that U does not compensate D_E for the larger fixed cost of entry f when U adopts two-part tariffs and makes take-it-or-leave-it offers. More importantly, condition (16) can be rewritten as $\Pi^*(c) = \pi_I^a + \pi_U^a < \pi_I^r + \pi_U^r = \Pi^*(kc) - f$, which implies that condition (5) never holds. Therefore, an exclusion equilibrium does not exist.

Proposition 5. *Suppose that the downstream firms are undifferentiated Bertrand competitors. When U adopts two-part tariffs and makes take-it-or-leave-it offers, entry is a unique equilibrium outcome if U can commit to input prices before the entry decision of D_E.*

Note that this result highly depends on the assumption that U makes take-it-or-leave-it offers, which allows U to earn all the joint profits with D_I when it trades with D_I by not committing to its contract term. In Appendix C, we explore the case where industry profits are allocated by bargaining and show that like price discrimination on linear pricing, there exists an exclusion equilibrium even when U can overcome the commitment problem.

From the above discussions, we can conclude that this study is most suitable for a discussion on the anticompetitiveness of exclusive supply agreements in industries where upstream firms employ simple linear pricing contracts. This subsection provides real-world examples of such industries. For example, linear pricing contracts are common in gasoline retailing and shipping industries (Lafontaine and Slade, 2013), and sometimes, employed in manufacturing industries, although non-linear pricing contracts are useful in vertical coordination (Blair and Lafontaine, 2005; Nagle and Hogan, 2005). Even in terms of franchise contracts, franchisors face several problems in using franchise fees (fixed payments) as their means of compensation; for instance, the wealth constraints of franchisees and franchisor opportunism with a lump-sum fee (Blair and Lafontaine, 2005).[19] Finally, 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 real-world examples of licensing terms subject to FRAND commitments and linear pricing contracts.[20]

Furthermore, some economists have empirically found the presence of the double marginalization problem, which implies that the joint profit maximization is difficult in a real business situation (Park and Lee, 2002; Gayle, 2013). Therefore, when we apply the model of exclusive contracts to a real business situation, the results for linear pricing that generates the double marginalization problem cannot be neglected.

4.3 Efficiency measure

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

[19]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. Milliou, Petrakis, and Vettas (2009) provide a theoretical reason to employ linear pricing contracts. In addition, Inderst and Valletti (2009) explain real-world examples in which linear pricing contracts are employed.

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

product using one unit of input A and $0 < m < 1$ unit of input B:

$$c_I = w_A + c_B, \quad c_E = w_A + mc_B.$$

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

5 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 input produced by the upstream supplier, because they mainly analyzed entry deterrence in upstream markets. However, our study suggests that when we focus on entry deterrence in downstream markets by considering exclusive supply contracts, then the difference in transformational technology of input can be an important market element.

We find that when the incumbent and entrant differ in transformational technology of input produced by the upstream supplier, the downstream incumbent and upstream supplier sign exclusive supply contracts to deter socially efficient entry, even in the framework of the Chicago School argument, where a single seller, buyer, and entrant exist. In addition, the difference in transformational technology of input produced by the upstream supplier changes the relationship between the entrant's efficiency and possibility of exclusion: anticompetitive exclusive supply agreements are more likely to arise if the entrant's efficiency is at an intermediate level. These results provide new implications for antitrust agencies: it is necessary to focus on the efficiency measure when discussing the anticompetitiveness 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.

We also find that exclusive supply agreements based on difference in transformational technology are more likely to arise when upstream firms employ simple linear pricing contracts; price discrimination and two-part tariffs reduce the possibility of anticompetitive exclusive supply agreements. These results provide the following implications. First, exclusive supply agreements are more likely to be observed in industries where linear pricing contracts are employed. Second, a ban on input price discrimination makes exclusion possible because such a ban enforces upstream firms to employ simple linear pricing contracts.

Finally, we find that even when an upstream supplier adopts price discrimination and two-part tariffs, there remains a possibility of exclusion if the fixed cost of entry is large because these pricing contracts allow the upstream supplier to easily extract downstream firms' operating profits. Therefore, exclusive supply agreements are more likely to be observed in industries where downstream entry requires large fixed costs.

However, several outstanding concerns require further research. First is this study's relationship with other studies on anticompetitive exclusive dealings. For example, we assume that an upstream supplier firm is a monopolist. Drawing on the results in Oki and Yanagawa (2011), we predict that if we add upstream competition to our model, the likelihood of an exclusion equilibrium increases. Second is 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.

A Proofs of Results

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 Cases (i) and (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)

$$p^*(kw(k)) = w(k). \tag{17}$$

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

$$\text{Case (i)} \qquad \max_{w}\,(w - c)kQ(w) \;\; s.t. \;\; w \in [c, w(k)],$$
$$\text{Case (ii)} \qquad \max_{w}\,(w - c)kQ(p^*(kw)) \;\; s.t. \;\; w \in [w(k), \infty).$$

The first-order conditions are given as

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

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

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

$$H^{(i)}(w(k)) = Q(w(k)) + (w(k)-c)Q'(w(k)) > 0. \tag{18}$$

Using equation (17), $H^{(ii)}(w(k))$ can be rewritten as

$$H^{(ii)}(w(k)) = Q(w(k)) + (w(k)-c)kQ'(w(k))p^{*\prime}(kw(k)). \tag{19}$$

To explore the above equation's property, we need to derive $p^{*\prime}(z)$. The first-order condition of the profit maximization problem (6) becomes

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

The total differential of this equation leads to

$$p^{*\prime}(z) = \frac{Q'(p^*(z))}{2Q'(p^*(z)) + (p^*(z)-z)Q''(p^*(z))}. \tag{20}$$

Using equations (17), (18), (19), and (20), we have the following relationship:

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

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 domain $(w(k), \infty)$ if in Case (i), the interior solution does not exist on 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 there are three possibilities concerning the optimal input price for U:

1. An interior solution exists only on domain $(c, w(k))$ in Case (i).

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

3. Interior solutions exist on domain $(c, w(k))$ in Case (i) and $(w(k), \infty)$ in Case (ii).

In the first and second case, we have unique interior solutions. In the third case, we need to check which of the interior solutions is optimal (The method to check this is provided in Section 3.).

Q.E.D.

A.1.2 Proof of Lemma 4

By Lemmas 1 and 2, the first statement in Lemma 4 holds. We prove the second statement. For a sufficiently small k (as $k \to 0$), we have $\pi_U^{r(i)} < \pi_U^{r(ii)}$. However, for $k = 1$, we have $\pi_U^{r(i)} > \pi_U^{r(ii)}$. Because $\pi_U^{r(ii)}$ is strictly decreasing in k but $\pi_U^{r(i)}$ is strictly increasing in k, there exists $k' \in (0, 1)$ such that $\pi_U^{r(i)} = \pi_U^{r(ii)}$.

Q.E.D.

A.1.3 Proof of Proposition 3

Condition (5) holds if and only if $f \geq f^*$. From equations (8) and (15), we have

$$\Pi^*(kc) - (w^a - c)Q(p^*(w^a)) - f^* = (p^*(w^a) - c)Q(p^*(w^a)) > 0.$$

Hence, there exists $f > 0$ that simultaneously satisfies conditions (5) and (14). Therefore, exclusion is a unique equilibrium outcome for $f^* \leq f < \Pi^*(kc) - (w^a - c)Q(p^*(w^a))$.

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 and in A.2.1.2, we consider cases in which an exclusive offer is accepted and rejected by the upstream supplier.

A.2.1.1 Exclusive offer is accepted in Stage 1

When the exclusive offer is accepted in Stage 1, the equilibrium demand level for input becomes

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

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

$$\pi_U^a = \frac{(a-c)^2}{8b}, \ \ \pi_I^a = \frac{(a-c)^2}{16b}.$$

A.2.1.2 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 U and D_I are given as

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

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

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

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

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

The profits of U and D_I are given as

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

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

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

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

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 $c < \breve{C}(k)$, where

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

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

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

for all $0 < k < 1$, whenever we have $\pi_U^{r(i)} > \pi_U^{r(ii)}$, 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 $\pi_U^{r(i)} < \pi_U^{r(ii)}$, 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.

B Quantity Competition

B.1: Results

This appendix considers the existence of anticompetitive exclusive dealings to deter the socially efficient entry of D_E when downstream firms compete in quantity. In this appendix, we use linear demand; that is, the inverse demand for the final product $P(Q)$ is given by a simple linear function 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 B.1. *Suppose that the downstream firms compete in quantity. Then, there can be an exclusion equilibrium as 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 U is sufficiently efficient, that is, $0 \leq c < \overline{C}(k)$ and*

$$\overline{C}(k) = \begin{cases} \dfrac{a\left(2k^3 + 3k^2 + 3k - 7 + \sqrt{27(1-k)^2(-4k^4 - 12k^3 + 31k^2 - 26k + 10)}\right)}{(2k-1)(14k-13)(k^2-k+1)} & \text{if } c < \dot{C}(k), \\ \hat{C}(k) & \text{if } c \geq \dot{C}(k). \end{cases} \tag{21}$$

where $\hat{C}(k)$ is in (13) and

$$\dot{C}(k) = \frac{a\left(k^2 - k + 1 - \sqrt{3(1-k)^2(k^2-k+1)}\right)}{(2-k)(k^2-k+1)}. \tag{22}$$

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

Figure 5 summarizes the result in Proposition B.1. 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, 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 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 D_E becomes efficient. Under undifferentiated Bertrand competition, the production level of D_I is always zero and it does not depend on the degree of D_E's efficiency. By contrast, under Cournot competition, the production level of D_I is positive, and more importantly, an improvement in D_E's efficiency gradually reduces the production level of 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.

B.2: Proof of Proposition B.1

We consider each of the possible subgames after Stage 1. Note that when the exclusive offer is accepted by U, equilibrium outcomes coincide with the case of price competition in Appendix A.2.1.1. By contrast, when U rejects the exclusive supply offer, D_E enters the downstream market and U deals with D_I and D_E. Given w, the quantities supplied by the downstream firms are given as

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

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

Anticipating the outcome, 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

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

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 U and D_I are given as

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

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

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

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 U and D_I are given as

$$\pi_U^r=\frac{(a-kc)^2}{8b},\ \ \pi_I^r=0.$$

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

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

two local optimal input prices exist. We now determine the price that is better for U. The first input price leads to higher profits for U if and only if $c<\dot{C}(k)$ (see (22)). Therefore, if $c<\dot{C}(k)$, the optimal input price is the first w^r, and then, both D_I and D_E are active. Otherwise, it is the second w^r, and then, only D_E is active.

We explore whether an exclusion equilibrium exists by examining whether the inequality in (5) holds. Substituting the result in the previous subsection with the inequality in (5), we have the condition $0 < c < \bar{C}(k)$ (see (21)) in Proposition B.1. Therefore, an exclusion equilibrium exists for $0 \leq c < \overline{C}(k)$.

Q.E.D.

C Industry profits allocated by bargaining

C.1: Results

This appendix extends Section 4.2's model analysis to the case in which the industry profit in Stage 3 is allocated by a random-proposer bargaining model introduced in Fumagalli, Motta, and Rønde (2012). The bargaining procedure in this appendix is as follows. With probability $\beta \in (0, 1)$, U makes a two-part tariff contract, and with probability $1 - \beta$, active downstream firms make two-part tariff contracts. In this setting, Section 4.2's model can be interpreted as a special case of $\beta = 1$.

We first consider the case in which the exclusive supply offer is accepted in Stage 1. In Stage 3, with probability β, U makes a two-part tariff contract, and U earns $\Pi^*(c)$ while D_I earns nothing. By contrast, with probability $1 - \beta$, D_I makes the two-part tariff contract, and D_I earns $\Pi^*(c)$ while U earns nothing. As a result, the firms' equilibrium profits, excluding the fixed compensation x, are

$$\pi_U^a = \beta\Pi^*(c), \;\; \pi_I^a = (1 - \beta)\Pi^*(c). \tag{23}$$

We next consider the case in which the exclusive supply offer is rejected in Stage 1 and then, D_E enters the downstream market in Stage 2. In Stage 3, with probability β, U makes a two-part tariff contract and earns $\Pi^*(kc)$, while D_I and D_E earn nothing. By contrast, with probability $1 - \beta$, D_I and D_E compete in two-part tariff contracts. D_E earns $\Pi^*(kc) - \Pi^*(c)$ and U earns $\Pi^*(c)$, while D_I earns nothing. As a result, the equilibrium firms' profits are given as follows:

$$\pi_U^r = \beta\Pi^*(kc) + (1 - \beta)\Pi^*(c), \;\; \pi_I^r = 0, \;\; \pi_E^r = (1 - \beta)(\Pi^*(kc) - \Pi^*(c)). \tag{24}$$

We now consider a commitment problem by U. From (24), it is easy to see that unlike Section 4.2, D_E earns positive profits in Stage 3, which mitigates the commitment problem. However, there still exists the commitment problem for the larger fixed cost of entry.

Proposition C.1. *Suppose that the downstream firms are undifferentiated Bertrand competitors. Suppose also that firms adopt two-part tariffs and the bargaining procedure follows a random-proposer model. When U cannot commit to input prices before D_E's entry decision, exclusion is possible if the fixed cost of entry is not too small.*

1. *For* $0 < f \leq (1-\beta)(\Pi^*(kc) - \Pi^*(c))$*, entry is a unique equilibrium outcome.*

2. *For* $(1-\beta)(\Pi^*(kc) - \Pi^*(c)) < f$*, exclusion is a unique equilibrium outcome.*

Similar to Section 4, to avoid the commitment problem, assume that U can commit to two-part tariff contracts before D_E makes its entry decision. We also assume that the fixed cost of entry satisfies the following condition.

Assumption 3. *The fixed cost of entry is not too large, such that U welcomes the entry of D_E:*

$$(1-\beta)(\Pi^*(kc) - \Pi^*(c)) < f < \Pi^*(kc) - \beta\Pi^*(c). \tag{25}$$

If the first inequality of (25) does not hold, then D_E always enters the downstream market regardless of commitment. If the second inequality of (25) does not hold, then the entry of D_E is not profitable for U and U does not induce D_E to enter the downstream market.

When U rejects the exclusive supply offer in Stage 1, in Stage 2, U optimally chooses two-part tariff contracts, such that $\pi_U^r = \Pi^*(kc) - f$ and $\pi_I^r = \pi_E^r = 0$. This profit allocation is equivalent to Section 4.2. The crucial difference from Section 4.2 arises when U decides the trading partner after the exclusive supply offer is rejected in Stage 1. U prefers the entry of D_E for $\Pi^*(kc) - f > \beta\Pi^*(c)$, which can be rewritten as the second inequality of (25). By comparing (16) and (25), it is easy to see that when U does not have full bargaining power, it prefers the entry of D_E even for the larger fixed cost of entry. Hence, there exists f that simultaneously satisfies conditions (5) and (25).

Proposition C.2. *Suppose that the downstream firms are undifferentiated Bertrand competitors. In addition, suppose that U can commit to input prices before the entry decision, such that D_E always enters the market if the exclusive supply offer is rejected. When firms adopt two-part tariffs and the bargaining procedure follows a random-proposer model, an exclusion equilibrium is possible if the fixed cost of entry is sufficiently large.*

1. *For $(1-\beta)(\Pi^*(kc)-\Pi^*(c)) < f < f'$, entry is a unique equilibrium outcome, where*

$$f' = \Pi^*(kc) - \Pi^*(c). \tag{26}$$

2. *For $f' \leq f < \Pi^*(kc) - \beta\Pi^*(c)$, exclusion is a unique equilibrium outcome.*

C.2: Proof of Proposition C.2

Condition (5) holds if and only if $f \geq f'$. We show that f' satisfies condition (25). From equations (23) and (26), U welcomes the entry of D_E when the exclusive supply offer is rejected if and only if

$$\Pi^*(kc) - f' - \beta\Pi^*(c) = (1-\beta)\Pi^*(c) > 0,$$

which implies that the second inequality of (25) holds. By contrast, from equations (24) and (26), D_E cannot enter the downstream market in the absence of commitment if and only if

$$f' - (1-\beta)(\Pi^*(kc) - \Pi^*(c)) = \beta(\Pi^*(kc) - \Pi^*(c)) > 0,$$

which implies that the first inequality of (25) holds. Hence, there exist $f > 0$, which simultaneously satisfies conditions (5) and (25). Therefore, exclusion is a unique equilibrium outcome for $f' \leq f < \Pi^*(kc) - \beta\Pi^*(c)$.

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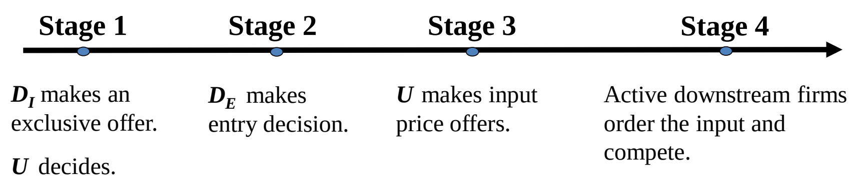

Figure 1: Time line

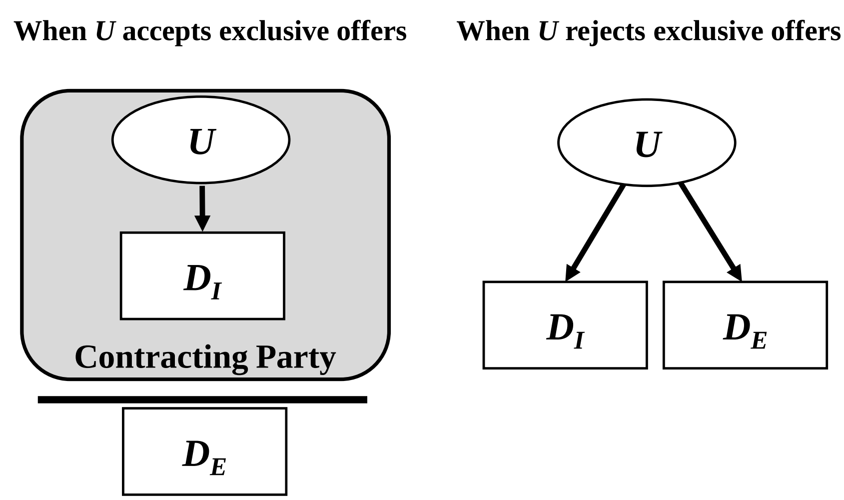

Figure 2: Wholesale price offers in Stage 3

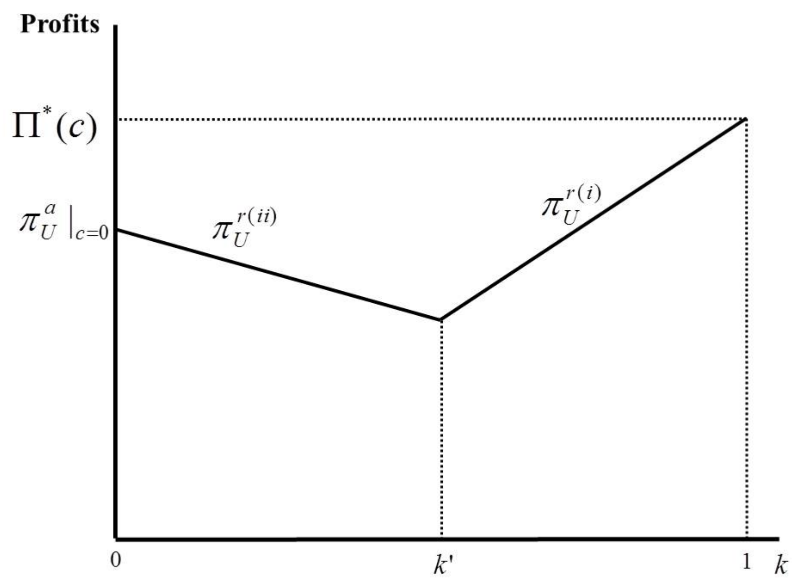

Figure 3: Properties of max $\{\pi_U^{r(i)}, \pi_U^{r(ii)}\}$

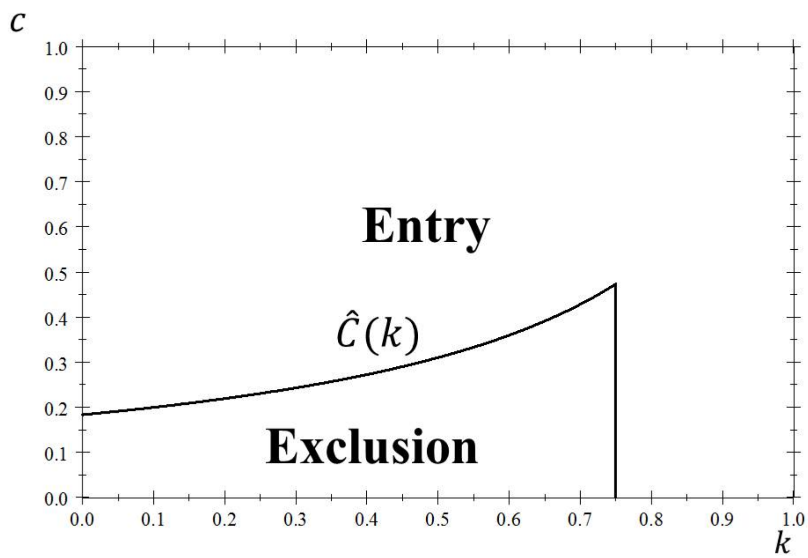

Figure 4: Results of Proposition 1 under linear demand (a = 1)

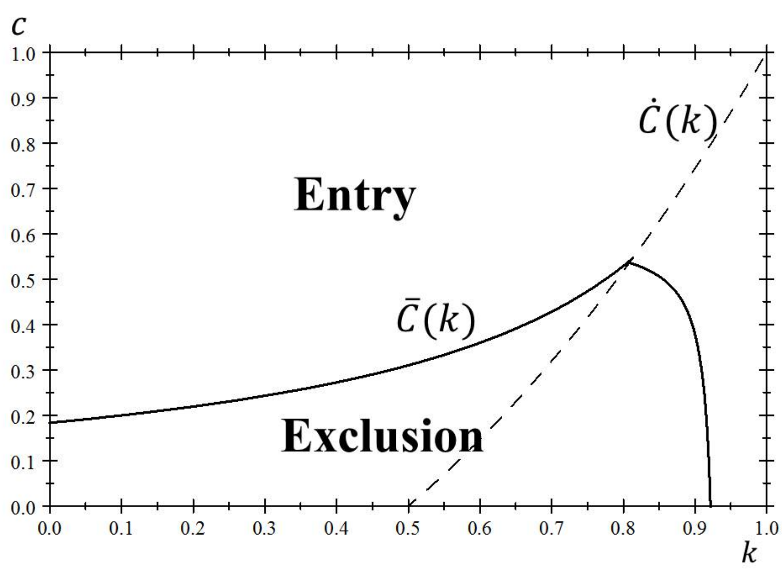

Figure 5: Results of Proposition B.1 (a = 1)