

Strategic Sourcing and Entry Deterrence ^{*}

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Abstract

We show that incumbent firms can use sourcing strategy to make binding commitments and communicate them to potential entrants, therefore deter the entrants' entry. By ordering key intermediate goods from an entrant, an incumbent is able to raise the entry barrier by convincing the entrant with an intense post-entry competition. At the same time, a joint surplus is generated and the entrant's loss from staying out is compensated. Entry-detering sourcing in general has ambiguous effect on social welfare. However, there can be scenarios where it enhances not only social welfare, but also consumers' welfare.

Keywords: Sourcing; Entry deterrence; Stackelberg Competition

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1 Introduction

Firms in general need to configure the supply of intermediate goods critical for their production. While they invariably endeavor to reduce their input cost as much as possible, literature reveals many strategic elements which may play a pivotal role in firms' sourcing decisions. This work identifies a mainly unnoticed strategic feature of sourcing, namely, its anticompetitive effect. We find that, an incumbent of final goods may outsource intermediate goods to a potential entrant solely for the purpose of deterring its future entry. Such incentive of entry deterrence can dominate cost minimization, leading the incumbent to purchase instead of producing the intermediate goods even when the entrant is less efficient than the incumbent in the intermediate goods production.

We analyze a simple setting with two firms: an incumbent and a potential entrant; and two goods: an intermediate good and a final good. Both the incumbent and the entrant can produce the intermediate good. To abstract from other determinants of sourcing, we assume that the incumbent is at least as efficient as the entrant in producing the intermediate good. If both firms act as independent producers, the entrant is profitable making some irreversible investment and engaging in final good production. These two firms interact in a three-stage game. In stage one, they decide whether or not there is outsourcing of the intermediate good from the incumbent to the entrant, together with the quantity to outsource. In stage two, the entrant makes its entry decision. In stage three, they engage in quantity competition upon the entrant's entry.

We find that, as long as the entrant's cost disadvantage for the intermediate good is not too pronounced, and the entry cost for the final good is not too small, in equilibrium the incumbent always outsources certain amount of the intermediate good to the entrant. As a consequence, the entrant's entry is deterred.

The effect of outsourcing in our model is two-fold. First, outsourcing offers an efficient way of information transmission from the incumbent to the entrant. As the entrant naturally gets informed the quantity it is obligated to supply, such quantity information, within a reasonable range, convinces the entrant with the incumbent's future production. If the entrant enters for the final good, it has to accommodate the incumbent's production by acting as a Stackelberg follower, thus is forced into a disadvantageous status. When the entrant observes a big enough quantity outsourced by the incumbent, it finds entry unprofitable. Second, outsourcing has a collusive effect. With entry deterred, the downstream market is kept monopolized and the entry cost is saved, leading to a joint surplus to the two firms. By supplying the incumbent, the entrant is compensated at least its profit it would otherwise get when it carries out entry. Even when the entrant turns out to be a less efficient producer of the intermediate good, these strategic effects of outsourcing can dominate the associated efficiency loss, inducing outsourcing to occur.

Although entry-detering outsourcing may involve an efficiency loss, it does not necessarily reduce the social welfare. In fact, outsourcing can improve social welfare either due to a large entry cost saved, or due to a large quantity produced for the final good. The latter case occurs when the entry cost is relatively small so that the incumbent needs to commit to a relatively big future quantity for the purpose of entry deterrence. Moreover,

there are scenarios where even consumers get benefited — if the entry cost is so small that deterring entry leads to a quantity exceeding the duopoly quantity, a larger amount is produced under outsourcing than what it would be otherwise, making consumers better off.

Our model does not impose exclusivity on the incumbent's make-or-buy decision. That is, the incumbent can always outsource as well as produce the intermediate good by itself. We find that, whenever outsourcing occurs, the incumbent fully outsources for relatively small entry cost. Instead, for relatively large entry cost and a strictly less efficient entrant, there is a mixture in the incumbent's sourcing strategy: the incumbent outsources exactly the threshold quantity needed for deterring the entrant's entry, and produces inside the remainder of its demand.

At the empirical level, we believe that our model is more applicable to industries where entry cost is big; in addition, the R&D investment is substantial for the entrant to develop technically superior final goods. For instance, in the aircraft industry, some sourcing practices might be anticompetitive. One observation is between Boeing and a Japanese consortium composed of the three biggest industrial giants of Japan: Mitsubishi Heavy Industries, Kawasaki Heavy Industries LTD, and Fuji Heavy Industries. These Japanese firms expressed an interest in entering the market for commercial aircrafts. Consequently, agreements were signed between Boeing and the Japanese firms. According to the agreements, Boeing would purchase from them the 767-X fuselage during the 1990s (*Chicago Tribune*, April 14, 1990), and then wings, together with related research and development during the 2000s (*Chicago Tribune*, December 21, 2003). Boeing's outsourcing to these Japanese firms cannot be easily justified based on cost-saving, since in the airline industry, costs in Japan "are just as high as or higher than at home" (*Newsweek International Edition*, May 15-22, 2006). Another observation is between Boeing and Lockheed. Although Lockheed exited the commercial aircraft market after 1981, it still possessed the production capability to reenter and compete with Boeing. Boeing signed a contract with Lockheed to purchase from Lockheed certain parts of commercial aircraft (*The Wall Street Journal*, May 10, 1989, p. 87). Subsequently, Lockheed never reentered the commercial aircraft market.

Our finding indicates that, everything else being equal, providers who pose a real entry threat are less likely to practice entry compared to entrants who are independent of the incumbent. It thus offers insight for a puzzling empirical finding, as shown below. As literature points out, there are good reasons for firms to beware that their key suppliers could turn into fierce competitors and lead to their detriment. For example, Caves and Porter (1977) argue that, "*important suppliers to an industry ... are often likely entry candidates*".¹ However, empirical findings tell quite a different story. Smi-

¹As listed out in Caves and Porter (1977), suppliers are likely to possess key elements for a successful entry, including well-established distribution or service networks, and the ability to produce components transformable into other commodities. One can also name other reasons for key suppliers to be likely entrant candidates. For example, it could be relatively easier for providers to infer information regarding the downstream market demand or consumers' tastes, or to grasp technology in converting the intermediate goods into the final products.

ley (1988) summarizes an extensive survey across a broad range of industries regarding what source of entry concerns them the most. One finding is, “*surprisingly few firms were concerned about new entrants ...from (among) their suppliers*”. While other factors might be at play, our work points out that, purchasing from potential entrants forms a channel of implicit collusion between buyers and sellers. As a result, suppliers could be *less* inclined to enter compared to independent entrants.

The rest of the paper is organized as follows. Section 2 discusses the related literature. The benchmark model and our analysis are given in Section 3. Section 4 derives our major findings. Section 5 discusses our results in several model variations to gain insights of their robustness. Section 6 then concludes.

2 Literature Review

The commitment power of outsourcing in our model is analogous to the commitment power of the incumbent’s capacity building (Spence (1977), Dixit (1979, 1980)). There are major differences between these two strategies. An easy-to-see point is that, since the incumbent alone makes its capacity decision, the collusive effect of outsourcing does not arise if the incumbent builds up sizable capacity for entry-deterrence purpose. More implicitly, capacity built by the incumbent may suffer observability problems and totally lose its value in entry deterrence, as pointed out in previous literature (Bagwell (1995), Várdy (2004)). Whereas, such problems are unlikely to arise when outsourcing is employed for entry deterrence. Section 5 gives more details of the analysis.

Our work shares a common spirit with Gelman and Salop (1983). In their work, the entrant pre-commits to a limited capacity of production to induce the incumbent to accommodate its entry. The findings in these two works — that by taking a less aggressive action, the entrant can share the profit with the incumbent — are qualitatively similar, although in our work there is no capacity limitation and the entrant fully restrains from the final good market. Besides, three major differences exist between these two works. Firstly, in Gelman and Salop (1983), it is the entrant who commits itself a soft competitor; while in our work it is the incumbent who commits to an aggressive response to entry. Secondly, in Gelman and Salop (1983), there is *no* entry without the entrant’s capacity restriction, thus their work is about entry accommodation. Instead, our work is on entry deterrence as there is always entry without the incumbent’s outsourcing. Thirdly, as it will be suboptimal for the incumbent to accommodate several entrants, the “judo economy” in Gelman and Salop (1983) becomes fragile when there are multiple entrants. However, in our work, the quantity the incumbent outsources to one entrant can erect entry barrier to *all* of the entrants. As shown in Section 5, outsourcing can be robust in entry deterrence with multiple entrants.

Another work in this line is Judd (1985). It shows that a multi-product incumbent may withdraw from some markets in response to entry, in order to protect its sale of substitutive goods. In Judd (1985), the entrant makes profit in horizontally related markets by restraining its production scope among substitutive goods. Complementarily,

our work illustrates that the entrant can glean profit in vertically related markets by restraining itself to upstream production.

To focus on our central point, we intentionally abstract from other factors which have influence on firms' sourcing decision. For example, the inclination to avoid fixed production cost (Shy and Stenbacka (2003)); the implicit collusion between a vertically integrated seller and its buyer (Chen (2001), Chen et al. (2004), Arya et al. (2008a)); the efficiency gain under diseconomies of scale (Spiegel (1993)); the incentive to raise rival's cost and soften downstream competition (Arya et al. (2008b), Buehler and Haucap (2006)); concerns about technology spillovers in outsourcing (Van Long (2005)); the tradeoff between production cost and monitoring cost (Shy and Stenbacka (2005)); etc.. More related to our work are Baake et al. (1998) and Chen et al. (2009), where they also recognize the endogenous leadership endowed to the buyer in outsourcing. Baake et al. (1998) examine the phenomenon that competing firms supply one another with their final products. The buyer becomes a Stackelberg leader by ordering from a competitor; at the same time, duplicate fixed cost is avoided. Chen et al. (2009) explore the outsourcing pattern when there exist both pure suppliers and vertically integrated suppliers. As a vertically integrated supplier suffers the Stackelberg follower's disadvantage through supplying its rival, it needs to charge a high price to remedy its loss, which may drive its rival to turn to a pure supplier for the supply. Our work, while also incorporating the leader-follower relationship induced by outsourcing, investigates a disparate economic phenomenon. In particular, we explore how the information transmitted in outsourcing binds buyers and sellers together and leads to their tacit collusion.

A rather sparse literature examines the viability of sourcing in entry deterrence in different contexts. Spiegel (1993) shows that when production exhibits diseconomies of scale, outsourcing to a potential entrant can enhance its future production cost and make it to stay out. In our work, outsourcing does not rely on the strict convexity of cost; it may arise even when the entrant faces economies of scale in its production, as shown in Section 5. Arya et al. (2008b) find that, outsourcing to a monopoly supplier pre-entry can induce it to supply the entrant with less favorable terms in the post-entry period, therefore deters the entrant's entry. Instead, in our work the incumbent orders directly from the entrant to deter its entry.

The anticompetitive effect of vertical integration has received lots of attention in literature on vertical foreclosure (see, e.g., Salinger (1988), Ordover et al. (1990), Rey and Tirole (2007)). As a complement, our work illustrates the anticompetitive effect of vertical disintegration. More related literature include Salop (1979), on the incumbent's capability in making entry-deterring binding commitments; Aghion and Bolton (1987), on exclusive contract and entry deterrence; Chen and Ross (2000), on the anticompetitive effect of alliances where incumbents and entrants share production capacity.

3 The Model and Analysis

The model consists of two firms: an incumbent firm 0 and a potential entrant firm 1 for a final good F . A key intermediate good I is required to produce good F . Firm 0 can produce both good I and good F , while firm 1 can only produce good I . By investing a fixed fee $K \geq 0$, firm 1 can acquire the same technology as firm 0 in converting good I into good F . Assume that is a fixed-coefficient technology such that one unit of good I can be converted into one unit of good F . W.l.o.g the constant average cost for producing good F is normalized to zero.

Producing good I incurs constant marginal cost c_0 for firm 0 and c_1 for firm 1.² To focus on the strategic aspect of outsourcing from firm 0 to firm 1, assume $c_1 \geq c_0$. Firm 1 may have a cost disadvantage in producing good I compared to firm 0.³

The inverse demand for good F is given by $P(Q)$, where Q is the total quantity of good F . For Q not too big such that $P(Q) > 0$, assume $P'(Q) < 0$, $P''(Q) \leq 0$, so that the existence and stability of Nash equilibrium in Cournot competition is guaranteed.

Consider a three-stage game, denoted as Game Γ :

Stage one. Firm 0 and firm 1 negotiate their transaction on good I in terms of $\{x_0^1, S\}$, with x_0^1 the quantity of good I firm 0 orders from firm 1,⁴ and S the total payment paid by firm 0 to firm 1.⁵ A binding contract is signed once they reach an agreement.

Stage two. Firm 1 decides whether or not to invest K and enter for good F .

Stage three. Firm 0 decides x_0 , the quantity of good I it produces inside, which firm 1 does not observe.⁶ If firm 1 enters, firms 0 and 1 simultaneously decide quantities of good F . If firm 1 does not enter, firm 0 decides its quantity for good F as a monopolist. Denote x_1 as the quantity of good I that firm 1 produces inside. Then the quantities of good F , given by q_0, q_1 , are subject to⁷ $q_0 \leq x_0 + x_0^1$; $q_1 \leq x_1 - x_0^1$.

Game Γ is solved by backward induction for subgame perfect Nash equilibrium (SPNE). Since $c_1 > 0$, it must be $x_1 = x_0^1 + q_1$ for firm 1 in any equilibrium. At the

²The linearity enables us to have a clear view of the central point. It is not critical to our analysis, though, as shown in Section 5.

³If $c_1 < c_0$, firm 0 is more readily outsourcing to firm 1 due to its incentive to minimize cost. Our analysis extends to the case when $c_1 < c_0$, as long as c_1 is not much smaller. If c_1 is much smaller than c_0 , firm 1 can drive out firm 0 and enjoy monopoly profit by entering the market of good F .

⁴Here we only allow for $x_0^1 \geq 0$. Section 5 gives a discussion on the case when we allow for $x_0^1 < 0$, i.e., firm 1 orders good I from firm 0.

⁵To focus on our central point, we consider a lump sum payment for the supply of good I , and do not explicitly assume how firms 0 and 1 split the surplus generated by outsourcing. Our major finding persists under alternative pricing schemes, including linear pricing and two-part tariff. See Section 5 for a discussion.

⁶Given the un-observability of x_0 to firm 1, it does not matter if x_0 is produced before or after firm 1's entry decision. For discussions on the un-observability of inside production, see Section 5.

⁷The inequality here is equivalent to assuming free disposal of good I for both firms. I.e., no cost will occur if either firm leaves some of its acquired good I unused, without converting them into good F .

terminal nodes of the game tree, profit for each firm is given by

$$\begin{aligned}\Pi_0^e(S, x_0, x_0^1, q_0, q_1) &= P(q_0 + q_1)q_0 - S - c_0x_0 \\ \Pi_1^e(S, x_0, x_0^1, q_0, q_1) &= P(q_0 + q_1)q_1 + S - c_1(x_0^1 + q_1) - K\end{aligned}$$

if firm 1 enters, and

$$\begin{aligned}\Pi_0^n(S, x_0, x_0^1, q_0) &= P(q_0)q_0 - S - c_0x_0 \\ \Pi_1^n(S, x_0, x_0^1, q_0) &= S - c_1x_0^1\end{aligned}$$

if there is no entry.

3.1 Stage Three

We start model analysis from stage three. Since $c_0 > 0$, in any equilibrium, firm 0 produces $x_0 = q_0 - x_0^1 > 0$ only if $q_0 > x_0^1$. There are two cases according to firm 1's entry decision in stage two.

Case I. Firm 1 enters.

In the simultaneous move in stage three, firm 1 maximizes $\Pi_1^e(S, x_0, x_0^1, q_0, q_1)$. Firm 0's problem is

$$\max_{q_0} \Pi_0^e(S, x_0^1, q_0, q_1) = \begin{cases} P(q_0 + q_1)q_0 - S - c_0(q_0 - x_0^1) & \text{if } q_0 > x_0^1 \\ P(q_0 + q_1)q_0 - S & \text{otherwise.} \end{cases}$$

Marginal cost of firm 0 in stage three is c_0 if $q_0 > x_0^1$, and 0 otherwise. Firm 0's best response curve is kinked at $q_0 = x_0^1$, as shown by the heavy curve in Figure 1. It overlaps OO' for $q_0 < x_0^1$ and MM' for $q_0 > x_0^1$. Firm 1's best response curve is RR' .

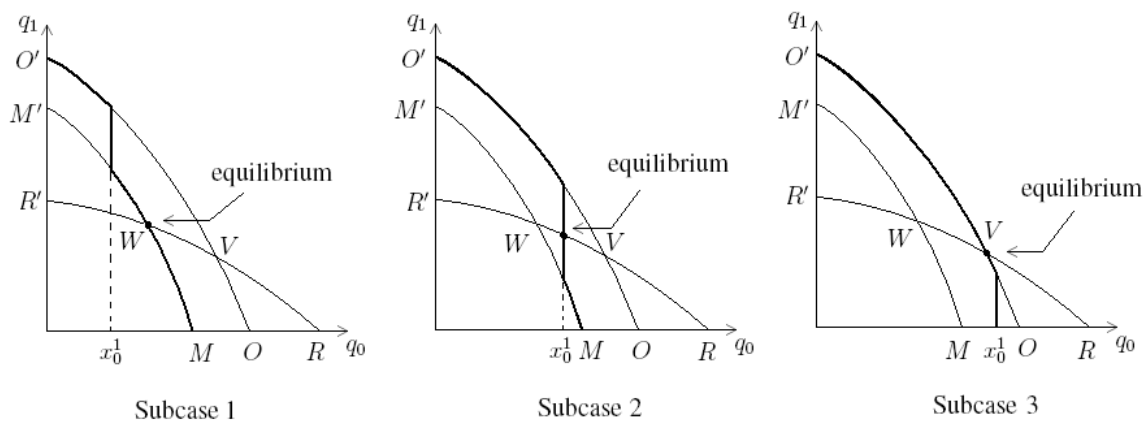


Figure 1: Post-entry Best Response Functions

Point W is the duopoly quantity when firm 0's marginal cost is c_0 , given by (q_0^W, q_1^W) ;⁸ point V is the duopoly quantity when firm 0's marginal cost is 0, given by (q_0^V, q_1^V) .

⁸We assume $q_1^W > 0$ throughout our analysis, otherwise firm 1 shall never enter.

Since the slopes of best response curves are within $(-1, 0)$, we have $q_0^W < q_0^V$. Denote q_0^M as firm 0's monopoly quantity at marginal cost c_0 , given by point M ; Denote q_0^O as firm 0's monopoly quantity at zero marginal cost, given by point O . Point R' gives firm 1's monopoly quantity, denoted as q_1^M . The monopoly profit is $\pi_0^M \equiv P(q_0^M)q_0^M - c_0q_0^M$ for firm 0, and $\pi_1^M \equiv P(q_1^M)q_1^M - c_1q_1^M$ for firm 1. Denote firm 0's quantity at point R as q_0^R . For $q_0 \geq q_0^R$, firm 1 is optimal producing zero quantity after its entry.

For any given q_i of firm i , denote firm j 's best response as $q_j^b(q_i) \geq 0, i, j = 0, 1, i \neq j$, solved from the first order condition $P'(q_i + q_j)q_j + P(q_i + q_j) - c_j = 0$. We have

$$\frac{d(q_i + q_j^b(q_i))}{dq_i} = 1 - \frac{P''q_j^b(q_i) + P'}{P''q_j^b(q_i) + 2P'} > 0. \quad (1)$$

Define $\pi_0^l(q_0), \pi_1^f(q_0)$ profits of firm 0 and firm 1 in the following way:

$$\pi_0^l(q_0) \equiv P(q_0 + q_1^b(q_0))q_0, \quad \pi_1^f(q_0) \equiv P(q_0 + q_1^b(q_0))q_1^b(q_0) - c_1q_1^b(q_0).$$

For $q_0 \in [0, q_0^R)$, $\pi_1^f(q_0)$ is strictly decreasing in q_0 since by the envelop theorem,

$$\frac{d\pi_1^f(q_0)}{dq_0} = P'(q_0 + q_1^b(q_0))q_1^b(q_0) < 0. \quad (2)$$

There are three subcases in stage three, as shown in Figure 1:

Subcase 1. $x_0^1 \in [0, q_0^W)$. Firm 0 and firm 1's best response functions intersect at point W . The NE quantities are $q_0(x_0^1) = q_0^W, q_1(x_0^1) = q_1^W$, with post-entry profit for firm 0 as $\pi_0^e(x_0^1) = P(q_0^W + q_1^W)q_0^W - c_0(q_0^W - x_0^1)$ and for firm 1 as $\pi_1^e(x_0^1) = P(q_0^W + q_1^W)q_1^W - c_1q_1^W$. In particular, at $x_0^1 = 0$, they get the standard Cournot profits:

$$\pi_0^W \equiv P(q_0^W + q_1^W)q_0^W - c_0q_0^W, \quad \pi_1^W \equiv P(q_0^W + q_1^W)q_1^W - c_1q_1^W.$$

Subcase 2. $x_0^1 \in [q_0^W, q_0^V]$. Firms' best response functions intersect at $q_0 = x_0^1$. Firm 0 produces exactly x_0^1 for good F . Understanding this, firm 1 produces $q_1^b(x_0^1)$ to maximize its profit of good F . Thus the quantity outsourced to firm 1 grants firm 0 a Stackelberg leader's advantage, and forces firm 1 to become a Stackelberg follower in the market of good F . At the given x_0^1 , their post-entry profits are $\pi_0^e(x_0^1) = \pi_0^l(x_0^1), \pi_1^e(x_0^1) = \pi_1^f(x_0^1)$, respectively. In particular, at $x_0^1 = V_0$, post-entry profits are

$$\pi_0^V \equiv P(q_0^V + q_1^V)q_0^V, \quad \pi_1^V \equiv P(q_0^V + q_1^V)q_1^V - c_1q_1^V.$$

Subcase 3. $x_0^1 \in (q_0^V, \infty)$. The best response functions intersect at point V . Equilibrium quantities are $q_0(x_0^1) = q_0^V, q_1(x_0^1) = q_1^V$. Firm 1 has $(x_0^1 - q_0^V)$ amount of good I it ordered from firm 1 left unutilized. Post-entry profit is $\pi_0^e(x_0^1) = \pi_0^V$ for firm 0, and $\pi_1^e(x_0^1) = \pi_1^V$ for firm 1.

Case II. Firm 1 stays out.

As a monopolist of good F , firm 0's problem is

$$\max_{q_0} \Pi_0^n(S, x_0^1, q_0) = \begin{cases} P(q_0)q_0 - S - c_0(q_0 - x_0^1) & \text{if } q_0 > x_0^1 \\ P(q_0)q_0 - S & \text{otherwise.} \end{cases}$$

The NE in stage three is: (i) if $x_0^1 < q_0^M$, firm 1 produces $x_0 = q_0^M - x_0^1$, and $q_0(x_0^1) = q_0^M$. (ii) If $x_0^1 \in [q_0^M, q_0^O]$, firm 0 does not produce good I , and $q_0(x_0^1) = x_0^1$. (iii) If $x_0^1 > q_0^O$, then $q_0(x_0^1) = q_0^O$ and $(x_0^1 - q_0^O)$ amount of good I is left unused.

The following lemma summarizes the NE and corresponding profits in stage three.

Lemma 1 *There exists a unique NE in stage three.*

I. When firm 1 enters,

(a) if $x_0^1 < q_0^W$, then $x_0 = q_0^W - x_0^1$, $(q_0, q_1) = (q_0^W, q_1^W)$, $\pi_0^e(x_0^1) = \pi_0^W + c_0x_0^1$, $\pi_1^e(x_0^1) = \pi_1^W$;

(b) if $x_0^1 \in [q_0^W, q_0^V]$, then $x_0 = 0$, $(q_0, q_1) = (x_0^1, q_1^b(x_0^1))$, $\pi_0^e(x_0^1) = \pi_0^l(x_0^1)$, $\pi_1^e(x_0^1) = \pi_1^f(x_0^1)$;

(c) if $x_0^1 > q_0^V$, then $x_0 = 0$, $(q_0, q_1) = (q_0^V, q_1^V)$, $\pi_0^e(x_0^1) = \pi_0^V$, $\pi_1^e(x_0^1) = \pi_1^V$.

II. When firm 1 stays out,

(a) if $x_0^1 < q_0^M$, then $x_0 = q_0^M - x_0^1$, $q_0 = q_0^M$, $\pi_0^n(x_0^1) = \pi_0^M + c_0x_0^1$;

(b) if $x_0^1 \in [q_0^M, q_0^O]$, then $x_0 = 0$, $q_0 = x_0^1$, $\pi_0^n(x_0^1) = P(x_0^1)x_0^1$;

(c) if $x_0^1 > q_0^O$, then $x_0 = 0$, $q_0 = q_0^O$, $\pi_0^n(x_0^1) = P(q_0^O)q_0^O$.

Given $\{x_0^1, S\}$, when firm 1 enters for good F , the equilibrium profit for each firm is

$$\Pi_0^e(S, x_0^1) = \pi_0^e(x_0^1) - S; \Pi_1^e(S, x_0^1) = \pi_1^e(x_0^1) - K + S - c_1x_0^1. \quad (3)$$

Instead, when firm 1 stays out, the equilibrium profit for each firm is

$$\Pi_0^n(S, x_0^1) = \pi_0^n(x_0^1) - S; \Pi_1^n(S, x_0^1) = S - c_1x_0^1. \quad (4)$$

3.2 Stage Two

Firm 1 makes its entry decision in stage two. W.l.o.g., we assume that if firm 1 is indifferent between entering or not, it stays out. Thus firm 1 enters for good F if and only if its post-entry profit exceeds the entry cost, i.e., $\pi_1^e(x_0^1) > K$. By Lemma 1 and the continuity of $\pi_1^f(x_0^1)$, we have $\pi_1^e(x_0^1) \in [\pi_1^V, \pi_1^W]$. If $K \geq \pi_1^W$, firm 1 never enters. By Bain's terminology (see Bain (1956)), *entry is blockaded*. Instead, if $K < \pi_1^V$, firm 1 always enters irrespective of the value of x_0^1 , and *entry is unavoidable*.

Define function $\tau(K) : [0, \pi_1^M] \rightarrow [0, q_0^R]$ as

$$\tau(K) \equiv \{q_0 | \pi_1^f(q_0) = K\}.$$

Notice that (i) $\tau(K) = 0$ if $K = \pi_1^M$; (ii) $\tau(K) = q_0^R$ if $K = 0$; (iii) $\tau(K)$ is strictly decreasing in K and c_1 as by the implicit function theorem,

$$\frac{d\tau(K)}{dc_1} = \frac{1}{P'(\tau + q_1^b(\tau))} < 0, \quad \frac{d\tau(K)}{dK} = \frac{1}{P'(\tau + q_1^b(\tau))q_1^b(\tau)} < 0. \quad (5)$$

From now on, we focus on $K \in [\pi_1^V, \pi_1^W)$ throughout our analysis of Game Γ . By Lemma 1, if $x_0^1 \leq q_0^W$, firm 1 should enter for good F since $\pi_1^W - K > 0$; if $x_0^1 > \min\{q_0^V, q_0^R\}$, firm 1 should stay out since $\pi_1^V - K \leq 0$. For $x_0^1 \in (q_0^W, \min\{q_0^V, q_0^R\}]$, by (2) and the fact that $\pi_1^f(q_0^W) = \pi_1^W > K$ and $\pi_1^f(\min\{q_0^V, q_0^R\}) = \pi_1^V \leq K$, the unique intersection of $\pi_1^f(x_0^1)$ and K is given by $x_0^1 = \tau(K)$. Thus $\tau(K)$ is the minimum amount of x_0^1 for entry to be unprofitable to firm 1. We have (i) $\tau(\pi_1^W) = q_0^W$; (ii) $\tau(\pi_1^V) = q_0^V$ if $q_0^V < q_0^R$ and $\tau(\pi_1^V) = q_0^R$ if $q_0^R \leq q_0^V$. Firm 1's entry rule is given below.⁹

Lemma 2 *In SPNE, firm 1 enters if and only if $x_0^1 < \tau(K)$, with $\tau(K) \in (q_0^W, \min\{q_0^V, q_0^R\}]$.*

Thus firm 0 is able to deter firm 1's entry by outsourcing $x_0^1 \geq \tau(K)$ to firm 1. The reason is, outsourcing to firm 1 reveals firm 1 the scale of firm 0's future production, hence forces firm 1 into a Stackelberg follower in the market of good F . When a big enough quantity is outsourced by firm 0, firm 1 understands that its Stackelberg follower's profit is no larger than the entry cost. As a consequence, firm 1 will stay out.

3.3 Stage One

Firms 0 and 1 make outsourcing decision in stage one. W.l.o.g, if both firms are indifferent between reaching an outsourcing agreement ($x_0^1 > 0$) and no outsourcing ($x_0^1 = 0$), we assume that no outsourcing will take place. Thus outsourcing from firm 0 to firm 1 occurs only when it generates a joint surplus to firms 0 and 1.

Notice that when firm 0 is anticipating firm 1 to enter, it may want to outsource to firm 1 for the Stackelberg leader's advantage in their future competition. However, the following lemma shows that there is no outsourcing in equilibrium when firm 1 enters.

Lemma 3 *In any SPNE, if firm 1 enters, it must be $x_0^1 = S = 0$, and profits for firm 0 and firm 1 are $(\Pi_0^e(0, 0), \Pi_1^e(0, 0)) = (\pi_0^W, \pi_1^W - K)$.*

Proof: See the Appendix. ■

The intuition is, when firm 1 is entering for good F , although firm 0 can be better off by outsourcing $x_0^1 > q_0^W$ to force firm 1 into a Stackelberg follower, total profit is smaller since the Stackelberg quantity is larger than the Cournot quantity. The upshot is, no outsourcing occurs and each firm produces the autarky duopoly quantity (q_0^W, q_1^W) and gets the standard Cournot profit. Therefore, whenever outsourcing arises, it is purely aimed at deterring firm 1's entry.

Denote $\xi^n(x_0^1) \equiv \Pi_0^n(S, x_0^1) + \Pi_1^n(S, x_0^1)$, the total industry profit without entry. By Lemma 1, Lemma 2 and (4), in outsourcing, firms' problem is

$$\max_{x_0^1} \xi^n(x_0^1) = \begin{cases} P(q_0^M)q_0^M - c_1x_0^1 - c_0(q_0^M - x_0^1) & \text{if } x_0^1 < q_0^M \\ P(x_0^1)x_0^1 - c_1x_0^1 & \text{if } x_0^1 \in [q_0^M, q_0^O] \\ P(q_0^O)q_0^O - c_1x_0^1 & \text{if } x_0^1 > q_0^O \end{cases}$$

s.t. $x_0^1 \geq \tau(K)$

⁹Since slopes of MM' and RR' are within $(-1, 0)$ and $q_1^W > 0$, we have $q_0^W < q_0^M < q_0^R$. Thus $(q_0^W, \min\{q_0^V, q_0^R\}] \neq \emptyset$.

The optimal x_0^1 is solved as $x_0^1(\tau)$, given by

$$\begin{cases} x_0^1(\tau) \in [\tau(K), q_0^M] & \text{if } \tau(K) \in (q_0^W, q_0^M] \text{ and } c_0 = c_1 \\ x_0^1(\tau) = \tau(K) & \text{otherwise.} \end{cases} \quad (6)$$

By Lemma 1 and (6), with firm 1's entry deterred, firm 0's equilibrium quantity is

$$q_0^d = \max\{q_0^M, \tau(K)\}.$$

Define $K^M \equiv \pi_1^f(q_0^M)$, thus $\tau(K^M) = q_0^M$ by the definition of $\tau(K)$. Notice that $K^M \in (0, \pi_1^W)$.¹⁰ By (5), $\tau(K) < q_0^M$ when $K > K^M$. In equilibrium where firm 1's entry is deterred, the industry profit is

$$\xi^n(K) = \begin{cases} \xi_1(K) \equiv P(q_0^M)q_0^M - c_1\tau(K) - c_0(q_0^M - \tau(K)) & \text{if } K \geq K^M \\ \xi_2(K) \equiv P(\tau(K))\tau(K) - c_1\tau(K) & \text{if } K < K^M \end{cases} \quad (7)$$

$\xi^n(K)$ is continuous in K and kinked at $K = K^M$. Outsourcing will arise in equilibrium if and only if $\xi^n(K)$ is larger than the total profit under entry. By Lemma 3, the condition is given as

$$\xi^n(K) > \pi_0^W + \pi_1^W - K. \quad (8)$$

4 Major Findings

Before we characterize the SPNE of Game Γ , it is useful to have the following lemma.

Lemma 4 *There exist \bar{K} and $\bar{c}_1 > c_0$, defined by*

$$\bar{K} \equiv \{K | \xi^n(K) = \pi_0^W + \pi_1^W - K\},$$

$$\bar{c}_1 \equiv \{c_1 | \pi_0^W + (c_1 - c_0)q_0^W - \pi_0^M = 0\}.$$

Condition (8) holds if and only if $K > \bar{K}$. Moreover, $\bar{K} < \pi_1^W$ when $c_1 < \bar{c}_1$.

Proof: See the Appendix. ■

Since outsourcing entails efficiency loss to the industry whenever $c_1 > c_0$, the profitability of entry deterrence requires that c_1 can not be much larger than c_0 . When this condition is satisfied, entry will be deterred for K not too small. The reason is, for very small K , a large quantity needs to be outsourced for firm 1 to stay out, which drives down the total profit in the market of good F , making entry deterrence undesirable.

Define

$$\Psi \equiv \begin{cases} [\pi_1^V, \pi_1^W) & \text{if } \bar{K} < \pi_1^V \\ (\bar{K}, \pi_1^W) & \text{if } \bar{K} \geq \pi_1^V. \end{cases}$$

$\Psi \neq \emptyset$ when $c_1 < \bar{c}_1$. The following theorem gives our major findings.

¹⁰By (2), $\pi_1^W = \pi_1^f(q_0^W) > \pi_1^f(q_0^M) = K^M$. By (1), $q_0^R = q_0^R + q_1^b(q_0^R) > q_0^W + q_1^W > 0 + q_0^b(0) = q_0^M$. Again by (2), $K^M > \pi_1^f(q_0^R) = 0$.

Theorem 1 For $K \in [\pi_1^V, \pi_1^W)$ and $c_1 \in [c_0, \bar{c}_1)$, the SPNE of Game Γ is characterized below:

I If $K \in \Psi$, firm 1's entry is deterred. In any SPNE, $x_0^1 \geq \tau(K)$ and $S \in [c_1 x_0^1 + \pi_1^W - K, \xi^n(K) - (\pi_0^W + \pi_1^W - K)]$. In particular,

(a) when $K \geq K^M$, (i) $x_0^1 = \tau(K)$ if $c_1 > c_0$ and (ii) $x_0^1 \in [\tau(K), q_0^M]$ if $c_1 = c_0$. Firm 0 produces $x_0 = q_0^M - x_0^1, q_0 = q_0^M$;

(b) when $K < K^M$, $x_0^1 = \tau(K)$. Firm 0 produces $x_0 = 0, q_0 = \tau(K)$.

II If $K \notin \Psi$, firm 1's entry is accommodated. There is a unique SPNE, where $x_0^1 = 0, q_0 = x_0 = q_0^W, q_1 = x_1 = q_1^W$.

Proof: See the Appendix. ■

Our major result for $c_1 \in [c_0, \bar{c}_1)$ is also illustrated in Figure 2, where K varies on the axis. To have the whole picture, we also allow for $K < \pi_1^V$ and $K \geq \pi_1^W$.

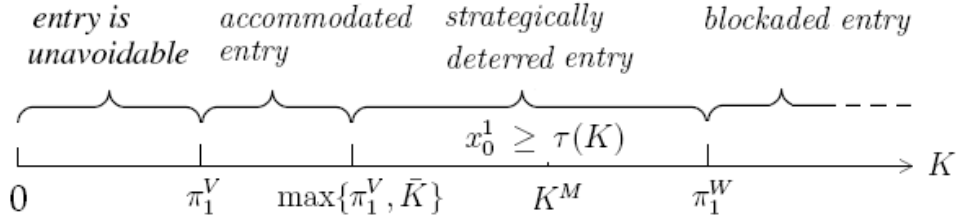


Figure 2: SPNE

Two strategic effects exist when firm 0 outsources to firm 1. On the one side, $x_0^1 \geq \tau(K)$ commits to a sizable future quantity of firm 0, acting as an entry barrier to firm 1; on the other side, there is a collusive effect. By keeping the downstream market more concentrated, a joint surplus is generated and split between firms 0 and 1 through their transaction on good I , making each better off compared to the autarky case.

We then check the welfare effect of outsourcing. Consider $c_1 \in [c_0, \bar{c}_0)$ and $K \in \Psi$. We define social welfare as the summation of firm surplus and consumer surplus. It is clear that firms are better off under outsourcing, yet consumers may get worse off when outsourcing reduces the quantity of good F . Let us take no outsourcing as the status quo, then $Q^W \equiv q_0^W + q_1^W$ is the status quo quantity. Status quo social welfare is $SW^S = \int_0^{Q^W} Pdq - c_0 q_0^W - c_1 q_1^W - K$; and social welfare under outsourcing is $SW^O = \int_0^{q_0^d} Pdq - c_1 \tau - c_0 (q_0^d - \tau)$. Outsourcing generates a distortion in social welfare, given as

$$\begin{aligned}
 D(K) &= SW^O - SW^S \\
 &= \begin{cases} K + \int_{Q^W}^{q_0^M} Pdq + [c_0(q_0^W - q_0^M + \tau) + c_1(q_1^W - \tau)] & \text{if } K \geq K^M \\ K + \int_{Q^W}^{\tau} Pdq + [c_0 q_0^W + c_1(q_1^W - \tau)] & \text{if } K < K^M \end{cases}
 \end{aligned}$$

$D(K)$ includes three parts: the saving of entry cost K ; the distortion in welfare due to the quantity change from Q^W to $q_0^d = \max\{q_0^M, \tau(K)\}$; and the distortion in welfare due to the change in production cost. While the first part is positive, the second and last parts can be either positive or negative. The social welfare effect of outsourcing is in general ambiguous. There are two cases where outsourcing increases social welfare. In the first case, the entry cost is big and outsourcing enhances social welfare by preventing excessive entry. However, consumers are worse off since the quantity of good F is q_0^M , which is less than Q^W . In the second case, entry cost is relatively small, so that a quantity close to Q^W is produced for good F , restricting consumers' loss. When the moderate consumers' loss is dominated by the saving of the entry cost, social welfare increases. Moreover, consumers can be strictly better off when the entry cost is sufficiently low so that deterring entry leads to a quantity larger than Q^W . In particular, as long as $\pi_1^f(Q^W) \in \Psi$, outsourcing increases consumers' welfare for $K < \pi_1^f(Q^W)$.

Proposition 1 Consider $c_1 \in [c_0, \bar{c}_0)$ and $K \in \Psi$. If c_0 is not too small compared to c_1 , we have $\pi_1^f(Q^W) \in \Psi$. Outsourcing increases consumers' welfare for $K < \pi_1^f(Q^W)$.

Proof: See the Appendix. ■

■ **An Example.** Suppose $P = \max\{0, a - Q\}$, with $Q = q_0 + q_1$. Assume $(a + c_1)/2 > c_1 \geq c_0 > 0$. The first inequality prevents firm 0 from automatically becoming a monopolist. The following values are easily calculated:

$$q_0^M = \frac{a - c_0}{2}, q_0^R = a - c_1, q_0^W = \frac{a + c_1 - 2c_0}{3}, q_1^W = \frac{a + c_0 - 2c_1}{3}$$

$$\pi_0^M = \frac{(a - c_0)^2}{4}, \pi_0^W = \frac{(a + c_1 - 2c_0)^2}{9}, \pi_1^W = \frac{(a + c_0 - 2c_1)^2}{9}.$$

For $a/2 > c_1$, we have interior solutions for (q_0^V, q_1^V) , with

$$q_0^V = \frac{a + c_1}{3}, q_1^V = \frac{a - 2c_1}{3}, \pi_1^V = \frac{(a - 2c_1)^2}{9}.$$

Consider $K \in [\pi_1^V, \pi_1^W)$. For $x_0^1 \in [q_0^W, q_0^V]$, the Stackelberg follower's quantity of firm 1 is solved from $\max_{q_1} \{(a - x_0^1 - q_1)q_1 - c_1q_1\}$ as $q_1^b(x_0^1) = \frac{a - c_1 - x_0^1}{2}$. Its Stackelberg follower's profit is $\pi_1^f(x_0^1) = [a - x_0^1 - q_1^b(x_0^1)]q_1^b(x_0^1) - c_1q_1^b(x_0^1)$. Firm 1 stays out if $\pi_1^f(x_0^1) \leq K$. The threshold value of x_0^1 , below which firm 1 shall enter, is solved from $\pi_1^f(x_0^1) = K$ as

$$\tau(K) = a - c_1 - 2\sqrt{K}.$$

Moreover, $K^M = \pi_1^f(q_0^M) = \frac{(a + c_0 - 2c_1)^2}{16}$. It is easy to verify that $\tau(K) > q_0^M$ when $K < K^M$. The upper bound of c_1 at which entry can be deterred is solved from $\pi_0^W + (c_1 - c_0)q_0^W = \pi_0^M$ as

$$\bar{c}_1 = \frac{3\sqrt{5} - 5}{40}(5a + 5c_0 + 6\sqrt{5}c_0).$$

Note that $\bar{c}_1 \in (c_0, (a + c_1)/2)$. Moreover, if $c_0 < \frac{45-15\sqrt{5}}{(3\sqrt{5}-5)(6\sqrt{5}+5)}a \approx 0.364a$, $\bar{c}_1 < a/2$ holds and interior solution is guaranteed for $c_1 < \bar{c}_1$. Suppose this is true. For $c_1 \in [c_0, \bar{c}_1)$, there exists a non-empty range of K , under which firm 0 outsources to firm 1 to deter its entry. Here \bar{K} is solved from $\xi^n(K) = \pi_0^W + \pi_1^W - K$, with

$$\xi^n(K) = \begin{cases} (a - \tau(K))\tau(K) - c_1\tau(K) & \text{if } K \in [\pi_1^V, K^M] \\ (a - q_0^M)q_0^M - c_1\tau(K) - c_0(q_0^M - \tau(K)) & \text{if } K \in (K^M, \pi_1^W). \end{cases}$$

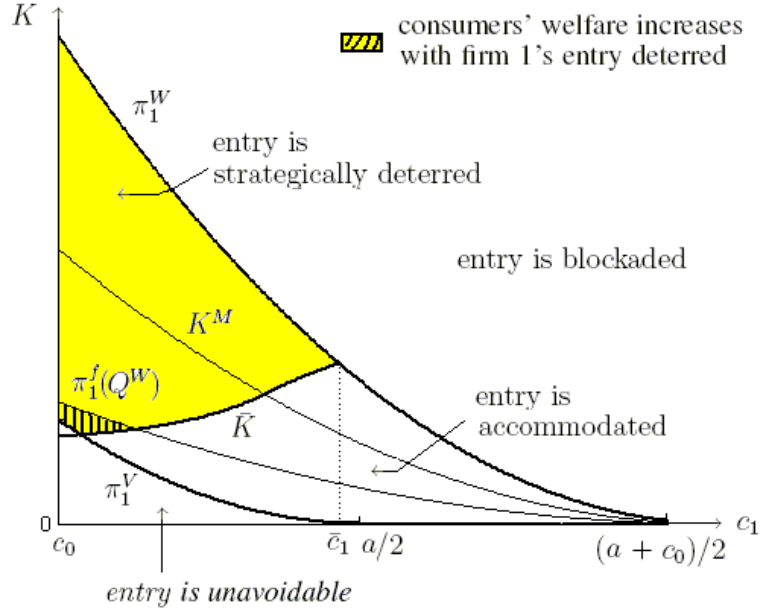


Figure 3: A Linear Example (Parameters are set as $a = 10, c_0 = 3.5$.)

Figure 3 shows the equilibrium entry strategy of this linear example. The shaded area gives the range of parameters where firm 0 outsources $x_0^1 \geq \tau(K)$ to deter firm 1's entry. In the hatched area, firm 1's entry is deterred and $K < \pi_1^f(Q^W) = \frac{7-3\sqrt{5}}{8}(a-c)^2$ is satisfied, implying that equilibrium quantity of good F is larger than Q^W . In this area, entry-detering outsourcing increases consumers' welfare.

5 Discussions and Model Variations

5.1 Alternatives of Quantity Revelation: Public Announcement or Capacity Building

A critical assumption in our model is that firm 0's inside production is unobservable to firm 1. However, it is clear that firm 0 has strong interests in revealing its quantity to firm 1. As outsourcing is costly in quantity revelation, a natural question is, why not firm 0 publicly announces its quantity to make firm 1 informed?

Suppose firm 0 publicly announces its quantity of good F before firm 1's entry decision. In the lack of an outside authority which can force firm 0 to fulfill its announcement, such announcement is just "cheap talk" and does not acquire the commitment power as outsourcing does. To see this, let firm 1 announces $q_0 \geq \tau(K)$ before firm 1's entry. If firm 1 enters, firm 0 is optimal accommodating entry by producing $q_0^W < \tau(K)$, rather than fulfilling its announcement. The unique post-entry equilibrium is (q_0^W, q_1^W) . In fact, any announced quantity larger than q_0^W is incredible to firm 1 and will be ignored when firm 1 chooses its optimal strategy.

Instead, Dixit (1980) shows that capacity built pre-entry by an incumbent credibly reveals its future quantity and serves entry deterrence. The similarity in capacity-building and outsourcing is, they strengthen the incumbent's competency in good F by sinking part of its production cost ahead of entry. However, as previous literature points out, capacity built by the incumbent suffers observability problems. If capacity is only observed with some noise, or if there is positive observation cost to the entrant, capacity built before entry may totally lose its value in entry deterrence.¹¹ This might explain to some extent the lack of empirical evidence on capacity building as constituting an entry barrier (see, e.g., Hilke (1984), Lieberman(1987), Goolsbee and Syverson(2008)). Instead, with outsourcing to deter entry, taking into consideration that entry deterrence now is in *both* firms' interests, it is reasonable to expect that the entrant knows the exact quantity it is obligated to supply to the incumbent. As a consequence, such observability problems will not arise when outsourcing is the ploy of entry deterrence.

Now suppose the incumbent's capacity built before entry is perfectly observable to the entrant at zero observation cost. We find that, there are still scenarios where capacity building is less effective than outsourcing in making quantity commitment. To see this, consider an extended game: at the very beginning, firm 0 chooses between building up its own capacity for good I , or outsourcing good I to firm 1 without building its own capacity. If outsourcing is chosen, Game Γ follows; otherwise firm 1 decides to enter or not after observing firm 0's capacity. In stage three, firm 0 can always enlarge its capacity if it wants to expand its quantity of good I . Firm 0's total average cost of good I consists of two parts: the average cost of capacity, given by $(1 - \alpha)c_0$; and the average cost of producing within the constructed capacity, given by αc_0 , $\alpha \in [0, 1]$.

Figure 4 depicts the SPNE entry-detering strategy adopted by firm 0 in the extended game. In the entry-detering regime, at a given K , firm 0 chooses to outsource rather than build capacity whenever α is not too small. The reason is, if firm 0 builds up capacity before firm 1's entry, it still faces at least αc_0 as its marginal cost after firm 1's entry. Instead, with outsourcing, firm 0 fully sinks c_0 and thus is able to threaten firm 1 with an even harsher post-entry competition. Whenever $\alpha > 0$, the quantity that firm 0 is able to commit to through capacity building is less than what it is through outsourcing. For relatively big α , $\tau(K)$ can lie beyond firm 0's commitment power under capacity

¹¹Bagwell (1995) shows that if the incumbent's capacity is only observed by the entrant with some non-zero noise, the commitment value of capacity may totally vanish regardless of how small that noise is. Várday (2004) finds that if observing the incumbent's capacity incurs some positive cost to the entrant, then the incumbent's commitment loses entirely its value, irrespective of the size of the observation cost.

building, leaving outsourcing the only vehicle for firm 0 to deter firm 1's entry.

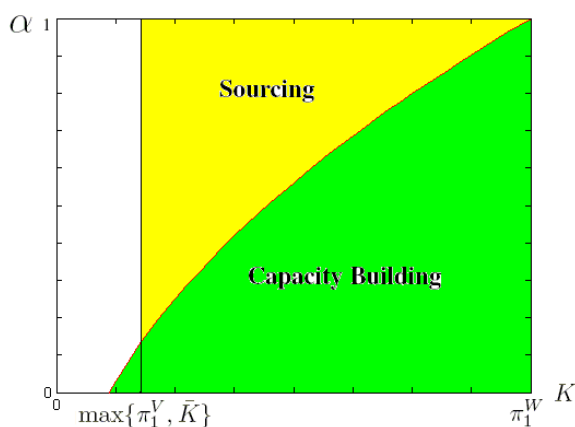


Figure 4: Sourcing vs. Capacity Building

5.2 Model Variations

To gain insights on the robustness of our basic results, we now consider several variations of our model. They are alternative pricing schemes in outsourcing; multiple potential entrants; price competition for good F ; economies of scale in producing good I ; and allowing firm 1 to outsource good I to firm 0.

□ **Alternative Pricing Schemes.** Instead of a lump sum payment for good I , we now consider two different pricing schemes: linear pricing and two-part tariff.

Suppose linear pricing is used in outsourcing. In stage one, firm 1 announces price p at which it is willing to supply good I , then firm 0 orders x_0^1 . After that, stage two and stage three follow the same as in Game Γ . Analysis to the modified game proceeds as following. First, consider the case when firm 1 enters. Since $p \geq c_1 \geq c_0$,¹² firm 0 shall outsource only if it can benefit in the future by acting as a Stackelberg leader, implying $x_0^1 > q_0^W$. Foreseeing its loss as a Stackelberg follower by supplying firm 0, firm 1 will set p high enough so that it can recoup its loss as a follower in the market of good F . However, the upshot is, such high price induces firm 0 to turn to inside production, leading to no outsourcing in any equilibrium when firm 1 enters.¹³ Thus

¹²Firm 1 has no incentive to set $p < c_1$. If it stays out, it loses money for each unit of good I sold at a price lower than its average cost. If it enters, it suffers in the final good market as a Stackelberg follower when supplying firm 0, thus will never offer $p < c_1$ for good I .

¹³The case here when firm 1 enters is similar to the setting in Chen et al. (2009), although in their work firm 0 can not produce good I inside and there also exist pure suppliers of good I . They find that, outsourcing from firm 0 to firm 1 occurs in equilibrium only if firm 1 is sufficiently more efficient than other suppliers of good I . As this is ruled out in our setting, firm 0 never orders from firm 1 whenever firm 1 also produces good F .

Lemma 3 remains unaltered, meaning that the opportunity cost of entry deterrence to firm 1 is still $\pi_1^W - K$. Second, from firm 0's perspective, at a given p , its opportunity cost of entry deterrence is either π_0^W (its profit at $x_0^1 = 0$), or its optimal profit when $x_0^1 \in (q_0^W, \tau(K))$, the case when it lets firm 1 enter and then exploits its Stackelberg leader's advantage. Although the second case complicates our analysis to some extent, it has no impact on the qualitative part of our finding. In SPNE, there exists a range of parameters where firm 1 sets p such that firm 0 finds it optimal to outsource $x_0^1 = \tau(K)$ in order to deter firm 1's entry.

A similar analysis applies when two-part tariff $\{T, p\}$ is used in the market of good I , with T the fixed fee for $x_0^1 > 0$ and p the unit price. The key is, as there is no efficiency gain of outsourcing, whenever firm 1 enters for good F , no outsourcing shall occur and in equilibrium each firm gets their autarky profit. As such, both firms will find entry deterrence optimal whenever it implies a joint surplus compared to the autarky case.

Assuming a lump sum payment in our base setting has left ambiguity in how firms 0 and 1 split the joint surplus of entry deterrence. Although it is not in our central interests, both linear pricing and two-part tariff can pin down the rule of sharing for these two firms, with advantage awarded to the one who makes the first movement by proposing the outsourcing pricing scheme.

□ **Multiple Potential Entrants.** Suppose firm 0 faces $n > 1$ symmetric potential entrants, denoted as firms $1, \dots, n$.

First, consider the case when these entrants appear in sequential periods. Suppose firm 1 is the first one to appear and make its entry decision, followed by firm 2, etc.. Each entrant, before its entry decision, observes the entry decisions of all its predecessors. It also observes if firm 0's sourcing in previous periods is external or internal, but not necessarily the outsourced quantity. Nevertheless, by outsourcing $x_0^1(\tau)$ (given in (6)) to firm 1, firm 0 is able to deter all of the entrants from producing good F . The logic is as following. In the period when firm 1 appears, firm 0, through outsourcing $x_0^1(\tau)$ to firm 1, makes firm 1's entry unprofitable. When firm 2 appears, it understands that firm 0's quantity of good F is meant to deter the entry of firm 1. Such quantity is pre-determined through firm 0's outsourcing, and is still the amount firm 0 will produce if firm 2 enters. As a result, firm 2 also finds entering for good F unprofitable.

Second, suppose these entrants appear at the same time. They make simultaneous decisions whenever firm 1 moves in the baseline model, with all else kept the same. The solution concept to this game is sequential equilibrium. There can exist multiple equilibria, and it may occur in equilibrium that firm 0 outsources to some of the entrants to deter their entry and let the rest enter. Nevertheless, the strategy stated in Theorem 1, combined with an appropriate belief system, constitutes a sequential equilibrium in which entry is deterred for all potential entrants. To see this, w.l.o.g., let firm 0 outsource only to firm 1 quantity $x_0^1(\tau)$. Given that all the other entrants are not entering for good F , each entrant $i, i \neq 1$, correctly predicting the transaction between firms 0 and 1 thus foreseeing firm 0's future quantity as no less than $\tau(K)$, will not deviate to entering the

market of good F . Moreover, firm 1 will not enter for good F ; and none of firms 0 and 1 shall opt out of their outsourcing transaction, or deviate to $x_0^1 \in (0, \tau(K))$, as that will invite firm 1's entry and lead to their detriment. In this equilibrium, by outsourcing to and compensating firm 1 along, firm 0 deters all the entrants from producing good F .

□ **Bertrand Competition.** Our major finding in the baseline model goes through the case when firms 0 and 1 produce differentiated good F and compete in prices (p_0, p_1) upon firm 1's entry.

Assume the demand of each firm in stage three is $q_i(p_0, p_1), i = 0, 1$. All standard assumptions hold and a unique NE exists in their price competition. Given $x_0^1 > 0$ in stage one, if we draw a diagram of the best response functions in stage three, then the best response curve of firm 0 is again kinked, with the kinked part given by $q_0(p_0, p_1) = x_0^1$. For $q_0(p_0, p_1) < x_0^1$, firm 0's best response function is its first order condition when it faces zero marginal cost; while for $q_0(p_0, p_1) > x_0^1$, its best response function is its first order condition when it faces marginal cost c_0 . By manipulating x_0^1 within certain range, firm 0 is now able to commit to a lower future price p_0 (instead of a larger quantity as in Cournot competition) compared to its standard Bertrand price. Thus firm 0 is able to threaten firm 1 with a harsher competition on good F , leading firm 1 to deem entry unprofitable. At the same time, the collusive effect of outsourcing persists. The benefit of entry deterrence can exceed the cost it entails, making each firm better off. As such, a similar analysis as in the baseline model applies to price competition, and outsourcing can again arise in equilibrium for entry deterrence purpose. In fact, since Bertrand competition yields lower duopoly profit than Cournot competition, there exists an even stronger incentive for firms to engage in entry-detering outsourcing.

□ **Economies of Scale.** If firm 1's average cost for good I decreases in its quantity, outsourcing from firm 0 to firm 1 helps reducing firm 1's production cost, hence may induce firm 1 to enter for good F . Based on this insight, we check here whether the presence of economies of scale shall shatter our previous finding. We find that, the qualitative part of our major finding is well preserved.

We consider the simplest case when firm 1's average/marginal cost is decreasing linearly in quantity. Let firm 0 and firm 1 be equally efficient in good I , with production cost given by

$$C(q) = \begin{cases} cq - vq^2 & \text{for } q < \frac{c}{2v} \\ \frac{c^2}{4v} & \text{for } q \geq \frac{c}{2v} \end{cases}$$

which satisfies $C'(q) > 0, C''(q) < 0$ for $q < \frac{c}{2v}$. The market demand of good F is $P(Q) = \max\{0, a - Q\}$, with $0 < c < a < \frac{c}{2v}$. The last inequality guarantees that the equilibrium quantity of good I entails positive marginal cost. Moreover, $P''(Q)Q + P' - C'' < 0$ holds, which guarantees the existence and uniqueness of a post-entry pure strategy Nash equilibrium. Everything else is kept the same as in the base setting. Figure 5 illustrates our major finding, with the shaded area the range of parameters

where outsourcing occurs in equilibrium to deter firm 1's entry. We also briefly describe our finding below.

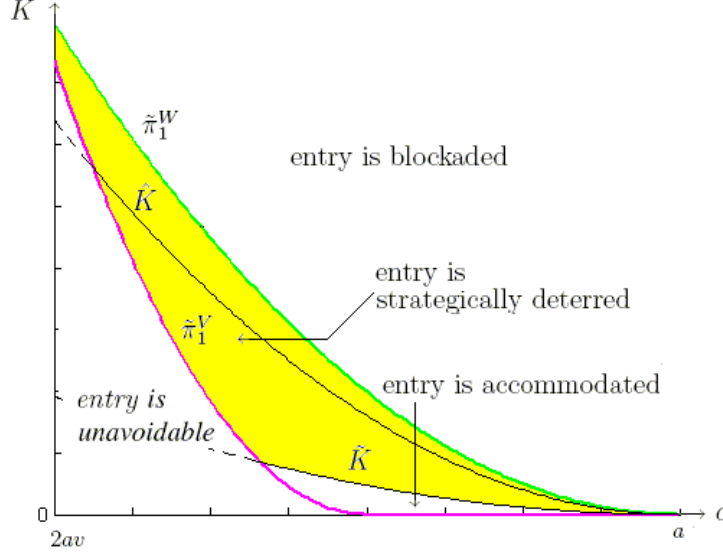


Figure 5: Under Economies of Scale (Parameters are set as $a = 10, v = 0.1$.)

Firm 0's monopoly quantity without entry threat is $\tilde{q}_0^M = \frac{a-c}{2(1-v)}$. Define $\tilde{\pi}_1^W \equiv \frac{(1-v)^3(a-c)^2}{(3-6v+2v^2)^2}$, $\tilde{\pi}_1^V \equiv (1-v)[\frac{(1+2v)a-2c}{3-2v}]^2$. If $K \geq \tilde{\pi}_1^W$, entry is blockedaded; if $K < \tilde{\pi}_1^V$, entry is unavoidable. Focusing on $K \in [\tilde{\pi}_1^V, \tilde{\pi}_1^W)$, the lowest value of x_0^1 for firm 1 to stay out is solved as $\tilde{\tau}(K) = \frac{a-c-2\sqrt{K(1-v)}}{1-2v}$. Define $\hat{K} \equiv \frac{(a-c)^2}{16(1-v)^3}$. In SPNE, when $K \geq \hat{K}$, $\tilde{\tau}(K) \leq \tilde{q}_0^M$ holds and firm 0 fully outsources its monopoly quantity to deter firm 1's entry. Instead, when $K < \hat{K}$, $\tilde{\tau}(K) > \tilde{q}_0^M$ holds. If firm 0 is to deter entry, it has to order $x_0^1 = \tilde{\tau}(K)$. In this case, entry is deterred if and only if $[a - \tilde{\tau}(K) - c]\tilde{\tau}(K) + v\tilde{\tau}(K)^2 \geq (\frac{a-c}{3-2v})^2 - K$, with the right-hand-side the optimal total profit when firm 1 enters. The value of K which solves this condition at equality is given by \tilde{K} .

Worthy of noting is that, in SPNE firm 0 fully outsources to firm 1 when it accommodates firm 1's entry. In fact, whenever firm 0 outsources, it produces zero amount of good I inside. These deviations from our findings to Game Γ are driven by firms' incentive to pursue scale economies.

□ **Allowing Firm 1 to Outsource.** Firm 1 may have interests to outsource good I to firm 0 when it is entering for good F .¹⁴ One reason is the efficiency gain if $c_0 < c_1$, the other reason is the Stackelberg leader's advantage in the market of good F . To explore the impact of firm 1's outsourcing incentive on our major finding, we analyze an extended game. In stage one, firm 0 and firm 1 negotiate their transaction on good I

¹⁴In our setting, firm 1 will never outsource good I whenever it stays out for good F .

in terms of $\{x_i^j, S\}$, with x_i^j the quantity of good I supplied by firm j to firm i , $i, j = 0, 1, i \neq j$, and S the total payment to the seller. Then stage two and stage three follow the same as in Game Γ , with q_0, q_1 in stage three subject to $q_0 \leq x_0 + x_0^1 - x_1^0$; $q_1 \leq x_1 + x_1^0 - x_0^1$.

There are two major findings.¹⁵ First, given firm 1's entry, firm 1 fully outsources good I to firm 0 if and only if $c_1 > c_0$; and in equilibrium $x_1^0 = q_1 = q_1^W$, $q_0 = q_0^W$, same as the autarky duopoly quantity. Second, our major finding is well preserved to the modified game. If $c_1 = c_0$, Theorem 1 is unaltered; if $c_1 > c_0$, in equilibrium entry-detering outsourcing still arises, but within a smaller range of parameters. For more details, notice that when $c_1 > c_0$, allowing firm 1 to outsource to firm 0 changes the opportunity cost of entry deterrence from $\pi_0^W + \pi_1^W - K$ to $[P(Q^W) - c_0]Q^W - K$. Firm 0 will outsource to firm 1 to deter its entry if and only if

$$\xi^n(K) > [P(Q^W) - c_0]Q^W - K. \quad (9)$$

It can be shown that there exist $\tilde{K} \geq \bar{K}$, $\tilde{c}_1 \in (c_0, \bar{c}_1)$, defined by

$$\tilde{K} \equiv \{K | \xi^n(K) = [P(Q^W) - c_0]Q^W - K\},$$

$$\tilde{c}_1 \equiv \{c_1 | \pi_0^W + (c_1 - c_0)Q^W - \pi_0^M = 0\}.$$

Condition (9) is satisfied if and only if $K \geq \tilde{K}$. Moreover, $\tilde{K} < \pi_1^W$ for $c_1 < \tilde{c}_1$. Define

$$\Phi \equiv \begin{cases} [\pi_1^V, \pi_1^W) & \text{if } \tilde{K} < \pi_1^V \\ (\tilde{K}, \pi_1^W) & \text{if } \tilde{K} \geq \pi_1^V, \end{cases}$$

We have $\Phi \neq \emptyset$ as long as $c_1 < \tilde{c}_1$. In SPNE to the modified game, for $K \in [\pi_1^V, \pi_1^W)$, (i) if $c_1 = c_0$ and $K \in \Psi$, firm 0 outsources $x_0^1 \in [\tau(K), q_0^M]$ to deter firm 1's entry; (ii) if $c_1 \in (c_0, \tilde{c}_1)$ and $K \in \Phi$, firm 0 outsources $x_0^1 = \tau(K)$ to deter firm 1's entry.

6 Conclusion

We have examined the role of sourcing in entry deterrence when the entrant is able to provide key intermediate goods. We find that, a final good producer may order an intermediate good from the entrant for the sole purpose of deterring its future entry. The reason is, first, the outsourced quantity convinces the entrant with a harsher post-entry competition, leading the entrant to deem entry unprofitable; second, outsourcing facilitates an implicit collusion and is mutually beneficial. Because outsourcing brings both firms the bonus of a more concentrated downstream market and the avoidance of the entry cost, it may occur even when the entrant happens to be a costlier producer of the intermediate good, as long as its cost disadvantage is not too significant.

We have exogenously assumed in our work a critical timing, namely, the quantity to outsource is determined before the entrant's entry decision. In fact, this timing can arise

¹⁵Details of the analysis are available upon request.

endogenously if we allow the entrant to choose either to make its entry decision prior to or following the incumbent's sourcing decision. It can be shown that, once outsourcing is negotiated after the entrant's entry, no outsourcing occurs and each firm gets the autarky duopoly profit. Therefore, whenever outsourcing arises in our base setting, it is still the case that the entrant will put its entry decision off until their outsourcing negotiation, in order to reap the surplus generated through the incumbent's entry deterrence.

Our model is readily extended to the case when the incumbent lacks comparable ability in producing the intermediate good and needs to choose its supply among multiple suppliers. Our finding stresses that, a supplier, by developing its entry potential, can become particularly attractive to the final good producer in the intermediate good market. However, there are many factors missing in our setting which may affect this result. To highlight the anticompetitive effect of sourcing of our central interests, we have ruled out the possibility that outsourcing is accompanied by technology leakage, which could help building the entrant's entry potential in a direct way.¹⁶ For example, the buyer may need to teach the seller related skill in order to guarantee high-quality supply. Besides, our finding is derived in a static setting. In the long run, an originally innocent supplier may gradually accumulate its tech know-how and innovate a superior final good through supplying the incumbent, thus may find entry irresistible at some threshold point of time. It can also be the case that, repeated interaction between buyers and sellers in the long-run facilitates a higher degree of collusion, leading to even less entry. All these factors, including the technology leakage and the sustainability of long-run collusion through outsourcing, are interesting future research.

Appendix

Proof of Lemma 3. Given firm 1's entry, at $x_0^1 = 0$, industry profit is $\pi_0^W + \pi_1^W - K$ by Lemma 1 and (3). $x_0^1 > 0$ can be in equilibrium only if it leads to a larger industry profit than $\pi_0^W + \pi_1^W - K$, otherwise at least one firm is better off opting out of their outsourcing transaction. Suppose $x_0^1 > 0$ in equilibrium. There are three cases: (i) $x_0^1 \in (0, q_0^W]$. By Lemma 1 and (3), industry profit is $\pi_0^W + \pi_1^W - K - (c_1 - c_0)x_0^1$. The industry is not better off, and is strictly worse off when $c_1 > c_0$. A contradiction. (ii) $x_0^1 > q_0^W$. Industry profit is $\pi_0^V + \pi_1^V - c_1x_0^1 - K$. By deviating to $x_0^1 = q_0^V$, industry profit can be improved to $\pi_0^V + \pi_1^V - c_1q_0^V - K$. At least one firm can be strictly better off with the other firm no worse off, again a contradiction. (iii) $x_0^1 \in (q_0^W, q_0^V]$. For such strategy to be in equilibrium, $\pi_0^l(x_0^1) + \pi_1^f(x_0^1) - c_1x_0^1 > \pi_0^W + \pi_1^W$ must hold, implying $[P(x_0^1 + q_1^b(x_0^1)) - c_1](x_0^1 + q_1^b(x_0^1)) > P(q_0^W + q_1^W)(q_0^W + q_1^W) - c_0q_0^W - c_1q_1^W$. By (1), $x_0^1 + q_1^b(x_0^1) > q_0^W + q_1^b(q_0^W) = q_0^W + q_1^W > 0 + q_1^b(0) = q_1^M$. By the strict concavity of

¹⁶Van Long (2005) analyzes a setting where outsourcing is associated with labor training in source country which benefits rival firms. As a result, firms tend to retain part of their demand to inside production, irrespective of the high labor cost of internal sourcing.

profit,

$$\begin{aligned} [P(x_0^1 + q_1^b(x_0^1)) - c_1](x_0^1 + q_1^b(x_0^1)) &< [P(q_0^W + q_1^W) - c_1](q_0^W + q_1^W) \\ &\leq P(q_0^W + q_1^W)(q_0^W + q_1^W) - c_0 q_0^W - c_1 q_1^W. \end{aligned}$$

A contradiction. Thus $x_0^1 \in (q_0^W, q_0^V]$ can not be in SPNE either. It must be $x_0^1 = 0$ whenever firm 1 enters. The rest part in the lemma follows immediately. \blacksquare

Proof of Lemma 4. Firstly, we prove that there exists a unique \bar{K} , such that (8) holds if and only if $K > \bar{K}$. We have

$$\frac{d(\xi^n(K) + K)}{dK} = \begin{cases} (c_0 - c_1) \frac{d\tau(K)}{dK} + 1 \geq 1 & \text{if } K \geq K^M \\ (P'\tau(K) + P - c_1) \frac{d\tau(K)}{dK} + 1 > 1 & \text{if } K < K^M \end{cases} \quad (10)$$

The first inequality follows (5) and $c_1 \geq c_0$; the second inequality follows (5), the strict concavity of profit, and $\tau(K) > q_0^M \geq q_1^M$ when $K < K^M$. Notice that $\pi_0^W + \pi_1^W$ does not vary in K . When $K = \pi_1^M > K^M$, we have $\tau(K) = 0$ and $\xi^n(K) + K = P(q_0^M)q_0^M - c_0 q_0^M + \pi_1^M = \pi_0^M + \pi_1^M > \pi_0^W + \pi_1^W$. When $K = 0$, $\tau(K) = q_0^R$ and $\xi^n(K) = [P(q_0^R) - c_1]q_0^R < [P(q_0^W + q_1^W) - c_1](q_0^W + q_1^W) \leq \pi_0^W + \pi_1^W$ since $q_0^R = q_0^R + q_1^b(q_0^R) > q_0^W + q_1^W > q_1^M$. There exists a unique intersection of $\xi^n(K)$ and $\pi_0^W + \pi_1^W - K$, given by $\bar{K} \in (0, \pi_1^M)$, and Condition (8) holds if and only if $K > \bar{K}$.

Secondly, we prove the existence and uniqueness of $\bar{c}_1 > c_0$. We start from showing that $\pi_0^W + (c_1 - c_0)q_0^W - \pi_0^M$ is monotonic in c_1 . Notice that (q_0^W, q_1^W) are solutions to the two first order conditions:

$$\begin{cases} P'q_0 + P - c_0 = 0 & F1 \\ P'q_1 + P - c_1 = 0 & F2 \end{cases}$$

By implicit function theorem, it is verifiable that

$$\frac{dq_0^W}{dc_1} = -\frac{\det(\frac{\partial(F1, F2)}{\partial q_1 \partial c_1})}{\det(\frac{\partial(F1, F2)}{\partial q_1 \partial q_0})} > 0, \quad \frac{dq_1^W}{dc_1} = -\frac{\det(\frac{\partial(F1, F2)}{\partial q_0 \partial c_1})}{\det(\frac{\partial(F1, F2)}{\partial q_0 \partial q_1})} < 0.$$

Hence

$$\frac{d\pi_0^W}{dc_1} = \frac{\partial\pi_0^W}{\partial q_1} \frac{dq_1^W}{dc_1} + \frac{\partial\pi_0^W}{\partial c_1} = P'q_0^W \frac{dq_1^W}{dc_1} > 0.$$

Thus $\pi_0^W + (c_1 - c_0)q_0^W - \pi_0^M$ is strictly increasing in c_1 , as π_0^M is invariant in c_1 and

$$\frac{d[\pi_0^W + (c_1 - c_0)q_0^W]}{dc_1} = \frac{d\pi_0^W}{dc_1} + q_0^W + (c_1 - c_0) \frac{dq_0^W}{dc_1} > 0.$$

At $c_1 = c_0$, it equals $\pi_0^W - \pi_0^M < 0$. When c_1 goes to its upper-bound such that $q_1^W = 0$, q_0^W goes to q_0^M and it goes to $\pi_0^M + (c_1 - c_0)q_0^M - \pi_0^M > 0$. There exists a unique $\bar{c}_1 > c_0$ which solves $\pi_0^W + (c_1 - c_0)q_0^W - \pi_0^M = 0$.

Thirdly, at $c_1 = \bar{c}_1$, we show that $\bar{K} = \pi_1^W$. By the definition of \bar{c}_1 , $P(q_0^M)q_0^M - \bar{c}_1 q_0^W - c_0(q_0^M - q_0^W) - \pi_0^W = 0$. Hence $\xi_1(K) = P(q_0^M)q_0^M - \bar{c}_1 q_0^W - c_0(q_0^M - q_0^W) = \pi_0^W + \pi_1^W - K$ is solved at $K = \pi_1^W > K^M$. By the uniqueness of \bar{K} at any given c_1 , $\bar{K} = \pi_1^W$ at $c_1 = \bar{c}_1$.

Lastly, we prove that $\bar{K} < \pi_1^W$ if $c_1 < \bar{c}_1$. Since $K^M < \pi_1^W$, when \bar{K} is solved from $\xi_2(K) = \pi_0^W + \pi_1^W - K$, $\bar{K} < \pi_1^W$ is trivially satisfied. Consider the case when \bar{K} is solved from $\xi_1(K) = \pi_0^W + \pi_1^W - K$. Define $f \equiv \xi_1(K) - \pi_0^W - \pi_1^W + K$. For $\bar{K} \geq K^M$, we have $\frac{d\bar{K}}{dc_1} = -\frac{df/dc_1}{df/dK}$. By (10), $\frac{df}{dK} = (c_0 - c_1)\frac{d\tau}{dK} + 1 > 0$. Recall that $Q^W \equiv q_0^W + q_1^W$. It is true that $\frac{dQ^W}{dc_1} = \frac{1}{3P'+P''Q^W} < 0$. Moreover,

$$\frac{d\pi_1^W}{dc_1} = \frac{\partial\pi_1^W}{\partial q_0} \frac{dq_0^W}{dc_1} + \frac{\partial\pi_1^W}{\partial c_1} = P'q_1^W \frac{dq_0^W}{dc_1} - q_1^W < 0.$$

Since $q_0^W \geq q_1^W$, $\frac{dq_1^W}{dc_1} < 0$, we have

$$\frac{d(\pi_0^W + \pi_1^W)}{dc_1} = P'q_0^W \frac{dq_1^W}{dc_1} + P'q_1^W \frac{dq_0^W}{dc_1} - q_1^W \geq P'q_1^W \frac{dQ^W}{dc_1} - q_1^W.$$

$$\begin{aligned} \frac{df}{dc_1} &= -\tau + (c_0 - c_1)\frac{d\tau}{dc_1} - \frac{d(\pi_0^W + \pi_1^W)}{dc_1} \\ &\leq q_1^W - \tau + (c_0 - c_1)\frac{d\tau}{dc_1} - P'(Q^W)q_1^W \frac{dQ^W}{dc_1} \\ &= q_1^W - \tau + \frac{P'(Q^W)(q_0^W - q_1^W)}{P'(\tau + q_1^b(\tau))} - P'(Q^W)q_1^W \frac{dQ^W}{dc_1} \quad (\text{by (5) and } F1, F2) \\ &\leq q_1^W - \tau + (q_0^W - q_1^W) - P'(Q^W)q_1^W \frac{dQ^W}{dc_1} \quad (\text{as } \tau + q_1^b(\tau) > Q^W, \frac{P'(Q^W)}{P'(\tau + q_1^b(\tau))} \in (0, 1]) \\ &= q_0^W - \tau - P'(Q^W)q_1^W \frac{dQ^W}{dc_1} < 0. \quad (\text{by Lemma 2, } \tau > q_0^W) \end{aligned}$$

Therefore $\frac{d\bar{K}}{dc_1} = -\frac{df/dc_1}{df/dK} > 0$, proving $\bar{K} < \pi_1^W$ for $c_1 < \bar{c}_1$. \blacksquare

Proof of Theorem 1. Proof of I. For $K \in \Psi$, Condition (8) holds and entry deterrence generates a positive surplus to the industry. In the market of good I , if firm 1 is just recouped its loss from staying out, $S = c_1 x_0^1 + \pi_1^W - K$; if firm 1 appropriates the whole surplus of entry deterrence, $S = \xi^n(K) - (\pi_0^W + \pi_1^W - K)$. For $S \in [c_1 x_0^1 + \pi_1^W - K, \xi^n(K) - (\pi_0^W + \pi_1^W - K)]$, no firm has incentive to deviate to no outsourcing. The rest part in I, (a) and (b) then follows (6), Lemma 1, Lemma 2 and Lemma 3.

Proof of II. For $K \notin \Psi$, Condition (8) is violated. The rest part then follows Lemma 1 and Lemma 3. \blacksquare

Proof of Proposition 1. Notice that $\pi_1^f(Q^W) < \pi_1^W = \pi_1^f(q_0^W)$. Thus the condition for $\pi_1^f(Q^W) \in \Psi$ is (i) $\pi_1^f(Q^W) \geq \pi_1^V = \pi_1^f(q_0^V)$ and (ii) $\pi_1^f(Q^W) > \bar{K}$. By (2), when $Q^W < q_0^V$, (i) is satisfied. Since $Q^W > q_0^M$, we have $\pi_1^f(Q^W) < K^M$ by (2). Moreover,

$\tau(\pi_1^f(Q^W)) = Q^W$. By (10), if $P(Q^W)Q^W - c_1Q^W + \pi_1^f(Q^W) > \pi_0^W + \pi_1^W$, (ii) is satisfied. Reorganizing the inequality gives $\pi_1^f(Q^W) > (c_1 - c_0)q_0^W$. If we fix the value of c_1 , then q_0^V is fixed. It can be shown that Q^W is decreasing in c_0 ; $\pi_1^f(Q^W)$ is increasing in c_0 ; and $(c_1 - c_0)q_0^W$ is decreasing in c_0 . Therefore, for c_0 relatively large, we have $Q^W < q_0^V$ and $\pi_1^f(Q^W) > (c_1 - c_0)q_0^W$, guaranteeing that $\pi_1^f(Q^W) \in \Psi$. ■

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