Entry Deterrence Through Strategic Sourcing

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Abstract

We show that a downstream firm may source to an upstream firm (the potential entrant) with the pure purpose of entry deterrence. The reason is, on one hand, a supplier is forced to be a Stackelberg follower upon its entry into the downstream market; on the other hand, the total surplus from keeping the downstream market concentrated and the saving of entry cost is shared through their transaction in the upstream market, making each better off. Under many circumstances, strategic entry-deterring sourcing improves social welfare. For some range of parameters, it even benefits consumers.

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1 Introduction

Seeking for appropriate suppliers is a crucial issue to any firm who demands intermediate product from outside. One possible concern is that there can be many channels for a key supplier to form entry threat to the downstream market, as pointed out in Caves and Porter (1977):

"Firms with well-established distribution or service networks, the ability to produce components transformable into other commodities, etc., are identifiable as likely entrants into a given industry (group). Similarly, important suppliers to an industry (group) ... are often likely entry candidates."

There are still other reasons for key providers to be likely entrant candidates than what listed out in Caves and Porter (1977). For example, it may be relatively easier for a provider to learn the market demand and the consumers' preference for the final product, or the technology to concert the intermediate product into the final product.

Intuitively a downstream firms should at least be cautious about the entry potential its major providers may possess. However, empirical finding tells a quite different story. Smiley (1988) summarized an extensive survey across a broad range of industries about what is the source of entry that concerns them most. One finding is,

"In the opinion of the respondents, the dominant source for potential entrants into existing product lines was existing rivals (who do not have similar products). Surprisingly few firms were concerned about new entrants ...from their suppliers ...." Moreover, *"manufacturing firms ...are less concerned about entry by related firms such as suppliers ...than are service sector firms."*

While the gap between the intuition and the real world left unfilled, our work shed light on the problem. We find that, under a large range of parameters, entry from a supplier is successfully blocked by an incumbent due to two reasons. Firstly, by sourcing a key component to the potential entrant, the incumbent can force the entrant to be a Stackelberg follower for the final product after its entry, therefore lower down the entrant's profit from entry to be zero. Secondly, by keeping the downstream market more concentrated, the total surplus generated is shared by the incumbent and the entrant through their transaction in the upstream market, leaving each better off than it would be otherwise. Therefore, the entrant is willing to accept the supplier's status and then stay out. In fact, the incentive to deter entry can dominate a firm's *sourcing* strategy, i.e. its choice of supplier, with the upshot that demand from a downstream firm is sourced in particular to an upstream firm who possesses entry potential, purely for the purpose of blocking future entry.

Note that the follower-ship of the supplier after its entry into the downstream market is endogenous to our model. Under very general assumptions, including that there is other resource of the intermediate product and free disposal of the incumbent, still it is true that the quantity ordered by the incumbent from the entrant can act as a commitment, forcing the entrant to accommodate as a follower.

There are some observations in real business world that a potential entrant is supplying an incumbent and does not really enter. One case is between Boeing and a Japanese

2

consortium, composed of three of Japan's biggest industrial giants: Mitsubishi Heavy Industries, Kawasaki Heavy Industries LTD, and Fuji Heavy Industries. These Japanese firms expressed their interest in entering the market for commercial aircraft. Right after that, agreements are signed between Boeing and these Japanese firms. According to the agreements, Boeing outsourced to them part of its production of the 767-X fuselage in 1990s (*Chicago Tribune*, April 14, 1990), then its production of wings, together with related research and development in 2000s.

Another case is between Lockheed and Boeing. Although Lockheed exited from the commercial aircraft market after 1981, it possesses the production capability to reenter and compete Boeing. Boeing signed a contract with Lockheed, sourcing its parts of commercial aircraft production to Lockheed. Lockheed never reentered the commercial aircraft market. (The Wall Street Journal, May 10, 1989, p. 87)[1].

This nature of strategic sourcing which deters entry may seem to be collusive, since both firms benefit from a less competitive downstream market. However, we show that counter intuitively, strategic sourcing generally improves social welfare. Moreover, in some circumstances it even improve consumer's welfare, because the total quantity produced for the final product when entry is deterred can be *larger* than the quantity produced under entry.

Whenever strategic entry-deterring sourcing occurs, it must also be the potential entrant's interest to act as a supplier and stay out, although it otherwise can compete the incumbent and achieve positive profit. In practice, government may deliberately regulate the industry's behavior in order to have a successful penetration in the final product market. One example is from Japanese government (see Aggarwal (2003), page 210). "The Japanese government identified semiconductors and computers as strategic industries as early as the 1950, and subsequently designed a comprehensive array of policies to foster their development, which provides domestic producers with a comprehensive advantage in domestic and international markets." One among these supportive policies is "prohibitions of the import of parts by U.S. subsidiaries". The success of these policies are documented. As a leading specialist in Japanese industrial policy argued, these unique policy incentives "cannot be ignored" in any explanation of the Japanese producers success in capturing a large slice of the American market.

The role of sourcing in entry deterrence has some similarity with the capacity construction by the incumbent (Spence (1977), Dixit (1979, 1980)), in the sense that both grants the incumbent a first mover's advantage. However, capacity suffers the observability problem to the entrant in order to have entry deterred, as has recognized by Bagwell (1995); whereas in case of sourcing the quantity ordered by the incumbent is naturally observed by the supplier. More importantly, capacity construction is a single-sided decision made by the incumbent, while strategic sourcing can never occur if the entrant is unwilling to take its role. Therefore, more strategic interaction between the incumbent and the entrant is involved when entry is deterred through strategic sourcing.

Other related literature to our work includes Chen and Dubey (2005), Chen et al.

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[1]These two observations are also cited in Spiegel (1993).

(2006). They found that the first mover's advantage of the buyer leads to strategic sourcing decision, that is, firms will purchase from a provider who are out of the final product market ("outsider") even if these providers have higher cost compared to those "insiders" (firms who also produce the final product). The first mover's advantage of a buyer is also identified in Bakke et. al. (1998) to explain cross-supplies, the phenomenon that two or more firms in the same industry supply each other with their final products.

Moreover, Spiegel (1993) finds that subcontracting can serve entry deterrence under the assumption of strictly convex production cost. Basu and Singh (1990) depicts the properties of entry deterrence in a Stackelberg game, with production cost for the entrant including an entry cost and a commencement cost. Chen and Ross (2000) finds the anti-competitive effect of alliance, in which capacity is shared hence a restrictive post-entry quantity is imposed to the entrant.

The rest of the paper is organized as follows. Section 2 describes the benchmark model with Cournot competition. Section 3 gives the major finding. Section 4, 5 and 6 shows the robustness of the major result with a different timing, with Bertrand competition, and with economies of scale for the intermediate product. Section 7 gives a generalization without specifying the post-entry competition rule.

2 The Model

The model consists of a monopoly incumbent, denoted as firm 0, for the final product good F. The only intermediate product required for producing good F is good I, which firm 0 can not produce. There exists a perfect competitive market for good I, from which firm 0 can purchase good I at the competitive price. Among the providers of good I, there exists a unique potential entrant for good F, denoted as firm 1, who by investing $K < \infty$, can acquire the same technology as firm 0 in converting good I into good F. All other firms who produce good I, denoted as firms 2,...,n, are symmetric to firm 1 except that they do not have the entry potential, or in other words, the required investment for them to be able to produce good F is infinity. The reason can be that only firm 1 has access to some critical technology or resource for producing good F.

Assume that one unit of good I can be converted into one unit of good F, and firm 0's constant average cost in converting good I into good F is normalized to zero. All firms $1, ..., n$ have the same technology (for simplicity) in manufacturing good I, with their constant marginal cost given as $c > 0$.

The inverse market demand on good F is given by $P(Q)$, with P the price and Q the total quantity produced for good F. Assume that $P(\cdot)$ is concave and strictly decreasing in Q for $Q < \bar{Q}$, with $\bar{Q}$ a large positive value.

The strategic interactions among these $n + 1$ firms are modelled as a three-stage game, denoted as game Γ.

In stage one, firm 0 proposes[2] firm 1 a take-it-or-leave-it offer, $\{p, x^1\}$, specifying

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[2]Our major conclusion is not affected wether firm 0 or firm 1 has the power in determining p and x^1,

that x^1 units of good I will be ordered by firm 0 from firm 1 at price[3] p. To make the offer non-trivial, $x^1 > 0$ must hold, otherwise no transaction will ever occur between firms 0 and 1. After that, firm 1 chooses either to accept or reject the offer. Only if it accepts the offer, a binding contract represented by $\{p, x^1\}$ is signed between them. This procedure is shown by Figure 1.
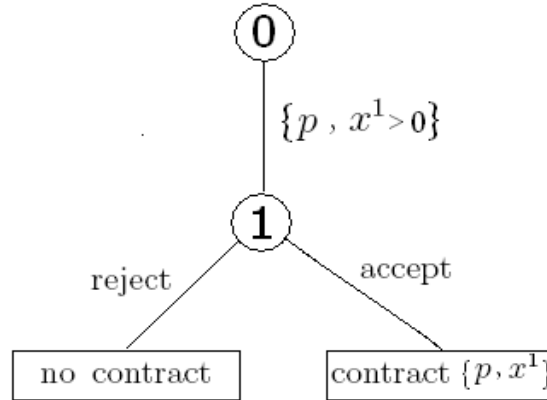

Figure 1: Bargaining Procedure in Stage One

In stage two, with the outcome in stage one observed, firm 1 decides wether to invest K to enter for good F or not.

Firm 0 observes firm 1's entry decision. In stage three, it can order more good I from firms $2, ..., n$, which firm 1 does not observe since it is confidential between firm 0 and the chosen provider. If firm 1 has entered, firms 0 and 1 simultaneously decide quantities $\{q_0, q_1\}$ to produce for good F, otherwise firm 0 decides q_0 along.

Since firms 2,...,n are symmetric, it does not matter to assume that firm 2 is firm 0's provider of good I whenever firm 0 orders from a firm other than firm 1. Denote x^2 as the quantity firm 0 orders from firm 2. Moreover, assume firm 0 has free disposal for the amount of good I it purchases[4].

Let d_0 represent firm 0's decision about to which one to order good I, with

$$d_0 = \begin{cases} 1 & \text{if firm 0 sources exclusively to firm 1} \\ 2 & \text{if firm 0 sources exclusively to firm 2} \\ BOTH & \text{if firm 0 sources to both firm 1 and firm 2.} \end{cases}$$

Let d_1 be firm 1's entry decision, with

$$d_1 = \begin{cases} 1 & \text{if firm 1 enters} \\ 0 & \text{o.w.} \end{cases}$$

as will be shown later.

[3]Our major conclusion keeps intact if non-linear pricing is allowed, i.e. instead of the unit price p, firm 0 offers a total payment for the quantity it orders.

[4]This is to make our assumption general. Without free disposal, the effectiveness of sourcing in entry deterrence can only be strengthened since the disposal cost helps to make firm 0's order of good I from firm 1 a commitment to its future quantity of good F.

What remains is to describe the profits for firms $0, 1, 2$ at the terminal notes. Denote the total profit to firm $i, i = 0, 1$ as $\Pi_i^e(p, x^1, x^2, q_0, q_1)$ if $d_1 = 1$, and $\Pi_i^{out}(p, x^1, x^2, q_0)$ if $d_1 = 0$. We have

$$\Pi_0^e(p, x^1, x^2, q_0, q_1) = P(q_0 + q_1)q_0 - px^1 - cx^2$$

$$\Pi_1^e(p, x^1, x^2, q_0, q_1) = P(q_0 + q_1)q_1 + (p - c)x^1 - cq_1$$

$$\Pi_0^{out}(p, x^1, x^2, q_0) = P(q_0)q_0 - px^1 - cx^2$$

$$\Pi_1^{out}(p, x^1, x^2, q_0) = (p - c)x^1$$

The game Γ is common knowledge. Solution concept employed for Γ is subgame perfect Nash equilibrium (SPNE), denoted simply by equilibrium in the following text.

3 Model Analysis and Major Result

3.1 Model Analysis

Begin our analysis from the last stage. With given $\{p, x^1\}$ and firm 1's entry decision, the subgame in stage three is denoted as $G(p, x^1, d_1)$. Denote firm $i, i = 0, 1$'s profit in $G(p, x^1, d_1)$ as $\pi_i^e(x^2, q_0, q_1)$ if $d_1 = 1$, and $\pi_i^{out}(x^2, q_0)$ if $d_1 = 0$.

Case I. Firm 1 has entered. I.e. $d_1 = 1$.

Firm 1's problem after entry is

$$\max_{q_1} \pi_1^e(q_0, q_1) = P(q_0 + q_1)q_1 - cq_1.$$

In equilibrium firm 0 will order $x^2 > 0$ only if $q_0 > x^1$. That is

$$x^2 = \begin{cases} q_0 - x^1 & \text{if} \quad q_0 > x^1 \\ 0 & \text{o.w.} \end{cases}$$

Since firm 0's expenditure on x^1 is already sunk, its problem is

$$\max_{q_0} \pi_0^e(q_0, q_1) = P(q_0 + q_1)q_0 - c(q_0 - x^1)I(q_0 > x^1)$$

where $I(q_0 > x^1) = 1$ if $q_0 > x^1$ and 0 otherwise. Firm 0's marginal cost in stage three is

$$\begin{cases} c & \text{if} \quad q_0 > x^1 \\ 0 & \text{o.w.} \end{cases}$$

Figure 2 depicts reaction functions for the two duopolists in stage three. Firm 1's reaction function is RR'. Two reference curves are given for firm 0's reaction function: OO' represents its reaction curve with zero marginal cost, and MM' represents its reaction curve with marginal cost c. At a given x^1, firm 0's reaction function is kinked at $q_0 = x^1$, which overlaps OO' for $q_0 < x^1$ and MM' for $q_0 > x^1$, shown by the
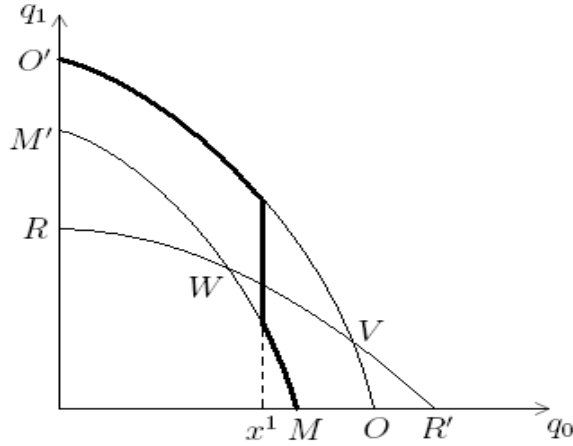
Figure 2: Reaction Functions in Stage Three

heavy kinked line in Figure 2. Denote the intersection of RR' and MM' as point W, the intersection of RR' and OO' as point V. The coordinates for W and V are given by $(W_0, W_1), (V_0, V_1)$ respectively.

With $x^1 > 0$, q_0 can be either bigger than, less than, or equal to x^1, because firm 0 can always expand x^1 by ordering also from firm 2, or leave some of x^1 unused when it produces good F. We have three subcases according to the value of x^1.

Subcase 1. $x^1 \in [0, W_0]$. Firm 0's reaction function intersects RR' at point W, implying that in equilibrium $q_0 = W_0, q_1 = W_1$, and firm 0 expands x^1 by ordering from firm 2 the quantity $x^2 = W_0 - x^1$. Define their profits in this subcase as $(\pi_0^c(x^1), \pi_1^c(x^1))$, with

$$\pi_0^c(x^1) \equiv P(W_0 + W_1) - c(W_0 - x^1), \quad \pi_1^c(x^1) \equiv P(W_0 + W_1)W_1 - cW_1.$$

Particularly, at $x^1 = 0$, firm 0 is ordering solely from firm 2 and its reaction function is MM'. Firm 1 knows that firm 0 must be ordering from firm 2, but does not know the quantity it orders. In this case these two firms are symmetric and they engage in standard Cournot competition, with their Cournot-Nash quantities given by (W_0, W_1) and corresponding profits given by

$$\pi_0^W \equiv P(W_0 + W_1)W_0 - cW_0, \quad \pi_1^W \equiv P(W_0 + W_1)W_1 - cW_1.$$

It is true that $\pi_0^W = \pi_1^W$.

Subcase 2. $x^1 \in (W_0, V_0]$. Firm 0's reaction function intersects RR' at $q_0 = x^1$. In stage three, firm 0 will neither set $x^2 > 0$, nor drop any of x^1. Firm 1 knows that $q_0 = x^1$ and its problem is

$$\max_{q_1} \pi_1^e(x^1, q_1) = P(x^1 + q_1)q_1 - cq_1.$$

Let $q_1^f(x^1)$ be the solution to the first order condition

$$P'(x^1 + q_1)q_1 + P - c = 0.$$

7

By setting $x^1 \in (W_0, V_0]$, firm 0 can get any point along segment WV as their competition outcome in stage three, thus is granted a Stackelberg leader's advantage along WV. On the other side, firm 1 produces $q_1^f(x^1)$ to accommodate the observed x^1, thus is acting as a Stackelberg follower. Define firms 0 and 1's profits $\pi_0^l(x^1)$ and $\pi_1^f(x^1)$ as

$$\pi_0^l(x^1) \equiv P(x^1 + q_1^f(x^1))x^1, \quad \pi_1^f(x^1) \equiv P(x^1 + q_1^f(x^1))q_1^f(x^1) - cq_1^f(x^1).$$

By envelope theorem,

$$\frac{d\pi_1^f(x^1)}{dx^1} = \frac{\partial\pi_1^f(x^1)}{\partial x^1} = P'q_1^f(x^1) < 0. \tag{1}$$

Denote the profits for firm 0 and firm 1 at $x^1 = V_0$ as

$$\pi_0^V \equiv P(V_0 + V_1)V_0, \quad \pi_1^V \equiv P(V_0 + V_1)V_1 - cV_1.$$

Note that $\pi_1^V < \pi_1^W$ since $\pi_1^f(x^1)$ is strictly decreasing along segment WV by (1).

Subcase 3. $x^1 > V_0$. Firm 0's reaction function intersects RR' at point V, hence in equilibrium $q_0 = V_0, q_1 = V_1$, and firm 0 has $x^1 - V_0$ of good I left idle. Denote their profits in this subcase as $(\pi_0^v(x^1), \pi_1^v(x^1))$. Since the cost of good I is sunk for firm 0, we have

$$\pi_0^v(x^1) = \pi_0^V, \quad \pi_1^v(x^1) = \pi_1^V.$$

The post-entry equilibrium quantity and profit for each firm are summarized by the following lemma.

Lemma 1 *If firm 1 enters the market of good F, their NE quantities are*

$$(q_0^e(x^1), q_1^e(x^1)) = \begin{cases} (W_0, W_1) & \text{if} & x^1 \leq W_0 \\ (x^1, q_1^f(x^1)) & \text{if} & x^1 \in (W_0, V_0] \\ (V_0, V_1) & \text{o.w.} \end{cases}$$

And NE profits in stage three are

$$(\pi_0^e(x^1), \pi_1^e(x^1)) = \begin{cases} (\pi_0^c(x^1), \pi_1^W) & \text{if} & x^1 \leq W_0 \\ (\pi_0^l(x^1), \pi_1^f(x^1)) & \text{if} & x^1 \in (W_0, V_0] \\ (\pi_0^V, \pi_1^V) & \text{o.w.} \end{cases}$$

A critical fact to our analysis is that $\pi_1^e(x^1)$ is strictly decreasing for $x^1 \in (W_0, V_0]$.
Case II. Firm 1 has stayed out, i.e. $d_1 = 0$.

Firm 0 is a monopolist for good F in this case. It chooses q_0 to maximize its monopoly profit, with $x^2 = q_0 - x^1$ if x^1 does not meet its demand on good I. It's problem is given by

$$\max_{q_0} \pi_0^{out}(q_0) = P(q_0)q_0 - c(q_0 - x^1)I(q_0 > x^1).$$

Let the coordinates of point M, O on the x-axis be (M_0, O_0) respectively. Then M_0 is firm 0's monopoly quantity with marginal cost c, and O_0 is its monopoly quantity with marginal cost zero. I.e.

$$M_0 \equiv \arg\max_{q_0} [P(q_0)q_0 - cq_0], \quad O_0 \equiv \arg\max_{q_0} P(q_0)q_0.$$

Denote firm 0's profit in stage three with $x^1 \leq M_0$ as

$$\pi_0^m(x^1) = P(M_0)M_0 - c(M_0 - x^1).$$

Lemma 2 gives firm 0's equilibrium quantity and profit.

Lemma 2 *If firm 1 stays out, the equilibrium quantity and profit in stage three are*

$$q_0^{out}(x^1) = \begin{cases} M_0 & if & x^1 \leq M_0 \\ x^1 & if & x^1 \in (M_0, O_0] \\ O_0 & o.w. \end{cases} \quad \pi_0^{out}(x^1) = \begin{cases} \pi_0^m(x^1) & if & x^1 \leq M_0 \\ P(x^1)x^1 & if & x^1 \in (M_0, O_0] \\ P(O_0)O_0 & o.w. \end{cases}$$

Now we are ready to move one stage back to stage two, in which firm 1 chooses wether or not to enter the market of good F. W.l.o.g., assume that firm 1 stays out if it is indifferent between entering or not. If firm 1 enters, its profit is $\pi_1^e(x^1) - K$, with $\pi_1^e(x^1)$ decreasing in x^1. Under a given x^1, firm 1's entry strategy depends on different values of K.

Case I. $K \geq \pi_1^W$. At $x^1 = 0$, i.e. no sourcing contract is reached in stage one, firm 1 will not enter since its profit upon entry is $\pi_1^W - K \leq 0$. Because $\pi_1^e(x^1)$ is constant for $x^1 \leq W_0$ and $x^1 > V_0$, and is strictly decreasing in x^1 otherwise, entry is never profitable for firm 1. By Bain's terminology, *entry is blockaded*. Firm 0 can act as if there exists no entry threat.

Case II. $K < \pi_1^V$. Even if firm 0 set $x^1 \geq V_0$, where V_0 is the highest quantity of x^1 which is credible to firm 1 as the future q_0 in their duopoly competition, it is still profitable for firm 1 to enter since it achieves $\pi_1^V - K > 0$ upon entry. Firm 0 lacks a effective vehicle to deter entry. We call this scenario as *entry can not be deterred*.

Case III. $K \in [\pi_1^V, \pi_1^W)$. By Lemma 1, if $x^1 \leq W_0$, firm 1 should enter to get $\pi_1^W - K > 0$; if $x^1 > V_0$, firm 1 should stay out since by entering it gets $\pi_1^V - K \leq 0$. For $x^1 \in (W_0, V_0]$, firm 1's post-entry profit $\pi_1^e(x^1) = \pi_1^f(x^1)$. By the strict monotonicity of $\pi_1^f(x^1)$ (see (1)) and the fact that $\pi_1^f(W_0) = \pi_1^W > K$ and $\pi_1^f(V_0) = \pi_1^V \leq K$, there exists a unique intersection of $\pi_1^f(x^1)$ and K. Firm 0's reaction function jumps down at some point on WV and coincides the horizontal axis thereafter, see the heavy curve in Figure 3.

When $K = \pi_1^W$, $\pi_1^e(x^1)$ intersects K at point W; when $K = \pi_1^V$, they intersect at point V. Define

$$\tau : [\pi_1^V, \pi_1^W] \to [W_0, V_0]$$
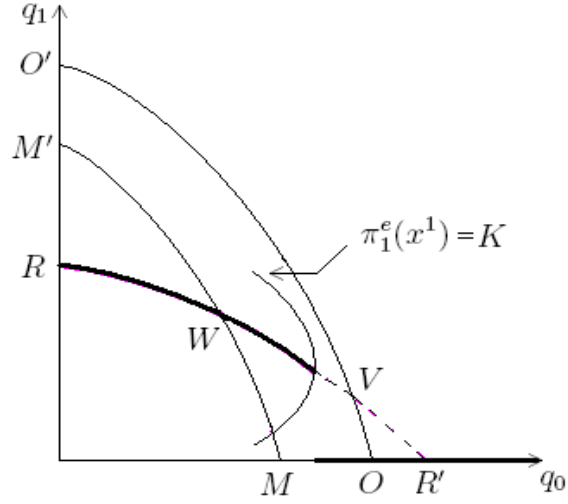
by

$$\tau(K) \equiv \{x^1 | \pi_1^f(x^1) = K\}.$$

Figure 3: Firm 1's Reaction Function

At a fixed K, τ gives the value of x^1 at which firm 1 is indifferent between entering and staying out. See the lemma below.

Lemma 3 *The function $\tau(K)$ is strictly decreasing. For any $K \in [\pi_1^V, \pi_1^W]$, $\pi_1^f(x^1) > K$ if $x^1 < \tau$; $\pi_1^f(x^1) < K$ if $x^1 > \tau$.*

Proof: Define $f \equiv \pi_1^f(x^1) - K$. By the implicit function theorem,

$$\frac{d\tau(K)}{dK} = -\frac{df/dK}{df/dx^1} = \frac{1}{P'q_1^f(x^1)} < 0.$$

The rest part follows our analysis above. ∎

Firm 1's entry rule is summarized by Lemma 4.

Lemma 4 *In any SPNE, firm 1 always stays out for $K \geq \pi_1^W$ and always enters for $K < \pi_1^V$. For $K \in [\pi_1^V, \pi_1^W)$, its entry decision is*

$$d_1 = \begin{cases} 0 & \text{if} \quad x^1 \geq \tau \\ 1 & \text{if} \quad o.w. \end{cases}$$

□

Now we back to stage one of game Γ, in which firms 0 and 1 decide $\{p, x^1\}$ for their transaction on good I, while keeping firm 1's entry rule into consideration. Denote $\Pi_i^e(p, x^1), i = 0, 1$ their profits when firm 1 is entering, and $\Pi_i^{out}(p, x^1), i = 0, 1$ their profits when firm 1 is staying out. From Lemma 1 and Lemma 2, it is straightforward to have

$$(\Pi_0^e(p, x^1), \Pi_1^e(p, x^1)) = (\pi_0^e(x^1) - px^1, \pi_1^e(x^1) + (p - c)x^1 - K)$$
$$(\Pi_0^{out}(p, x^1), \Pi_1^{out}(p, x^1)) = (\pi_0^{out}(x^1) - px^1, (p - c)x^1) \tag{2}$$

10

For simplicity, we denote the scenario that no contract is struck in stage one as $x^1 = 0$.

For $K \geq \pi_1^W$, entry is blockaded and firm 0 faces no real entry threat. Therefore, it will order $x^1 > 0$ to firm 1 only if $p \leq c$. On the other hand, firm 1 will never sign a contract with $p < c, x^1 > 0$ since it ends up with negative profit. Thus in any SPNE, it must be that either $p = c, x^1 \in (0, M_0], d_1 = 0, q_0 = x^1 + x^2 = M_0$, or $p \geq c, x^1 = 0, d_1 = 0, q_0 = x^2 = M_0$. Our analysis below will focus on the case when $K < \pi_1^W$. Moreover, $K \in [\pi_1^V, \pi_1^W)$ is of particular interests. For K in this range, if $x^1 = 0$, firm 1 will enter the market of good F. However, firm 0 by striking a contract with firm 1 committing $x^1 \geq \tau$, can successfully have firm 1 stay out in the future.

The following lemma tells us that if firm 1 enters, it is impossible for firms 0 and 1 to reach a contract characterized by $\{p > c, x^1 > 0\}$.

Lemma 5 *For $K < \pi_1^W$, in any SPNE if firm 1 enters, no contract characterized by $\{p > c, x^1 > 0\}$ can be reached in stage one.*

Proof: Suppose in some SPNE, firms 0 and 1 strike a contract with $p > c, x^1 > 0$, then in stage two firm 1 enters. It must be $x^1 \in (W_0, V_0]$. Firstly, if $x^1 \in (0, W_0]$, by Lemma 1 and (2), firm 0's profit is $\Pi_0^e(p, x^1) = \pi_0^c(x^1) - px^1 = P(W_0 + W_1)W_0 - px^1 - c(W_0 - x^1)$. Let firm 0 deviate to $x^1 = 0$. Firm 1 enters in stage two (by Lemma 4) but firm 0 gets $P(W_0 + W_1)W_0 - cW_0$ (by Lemma 1), a strict improvement since $p > c$. A contradiction. Secondly, if $x^1 > V_0$, by Lemma 1 and (2), firm 0 gets $\pi_0^V - px^1 = P(V_0 + V_1)V_0 - px^1$, with $(x^1 - V_0)$ amount of good I left idle. Firm 0 by deviating to $x^1 = V_0$ can be strictly better off (by Lemma 1). Firm 0 will deviate, again a contradiction. Hence it must be $x^1 \in (W_0, V_0]$. By Lemma 1, firm 0 gets $\Pi_0^e(p, x^1) = \pi_0^l(x^1) - px^1$, firm 1 gets $\Pi_1^e(p, x^1) = \pi_1^f(x^1) + (p - c)x^1 - K$. However, both firms 0 and 1 can choose to sign no contract in stage one. If so, firm 1 enters (by Lemma 4). By (2), firm 0 can guarantee itself payoff π_0^W by ordering $x^1 = 0$, also firm 1 can guarantee itself payoff $\pi_1^W - K$ by rejecting firm 0's offer. To ensure that none of them will deviate from $x^1 > 0$ to $x^1 = 0$, it must be true that none of them is strictly worse off under contract $\{p > c, x^1 > 0\}$, implying that

$$\Pi_0^e(p, x^1) \geq \pi_0^W, \qquad \Pi_1^e(p, x^1) \geq \pi_1^W - K$$

must hold at the same time. These two conditions together imply

$$[P(x^1 + q_1^f(x^1)) - c](x^1 + q_1^f(x^1)) \geq \pi_0^W + \pi_1^W. \tag{3}$$

However, it is never true. To see this, firstly, $[P(Q) - c]Q$ is strictly concave in Q and is maximized at $Q = M_0$ by the definition of M_0. Secondly, $W_0 + W_1 > M_0$, due to the fact that firm 0's Cournot reaction curve MM' has slope between $(-1, 0)$. Lastly, $x^1 > W_0$ implies that $x^1 + q_1^f(x^1) > W_0 + W_1$ since $\frac{dq_1^f(x^1)}{dx^1} > -1$. Hence $[P(x^1 + q_1^f(x^1)) - c](x^1 + q_1^f(x^1)) < [P(W_0 + W_1) - c](W_0 + W_1) = \pi_0^W + \pi_1^W$. Condition (3) is violated, proving the lemma. ∎

Moreover, if in any SPNE firm 1 enters, each of firms 0 and 1 gets the Cournot-Nash profit. See the following lemma.

Lemma 6 *In any SPNE, if firm 1 enters, it must be that either $p = c, x^1 \in (0, W_0]$, or $x^1 = 0$ (i.e., no contract is reached between firms 0 and 1). Profits for firm 0 is π_0^W and for firm 1 is $\pi_1^W - K$.*

Proof: By Lemma 4, $K < \pi_1^W$ holds since firm 1 enters. If $x^1 = 0$, by (2), the profits of firms 0 and 1 are π_0^W and $\pi_1^W - K$ respectively. If firm 1 enters following $x^1 > 0$ struck with firm 0, then it must be $x^1 \leq V_0$ (see the proof of Lemma 5) and $p \leq c$ (by Lemma 5). Suppose $x^1 \in (W_0, V_0]$. Firm 1 gets $\pi_1^f(x^1) + (p - c)x^1 - K$ (by Lemma 1 and (2)), which is strictly decreasing in x^1 by (1) and the fact $p \leq c$. Therefore, firm 1 is better off rejecting that $x^1 > 0$ ordered by firm 0 in stage one, to improve its profit to $\pi_1^W - K$. A contradiction. Hence in equilibrium $x^1 \leq W_0$ must be true. By (2), firm 1 gets $P(W_0 + W_1)W_1 - cW_1 + (p - c)x^1 - K$. It will reject $x^1 > 0$ if $p < c$. Therefore to have $x^1 > 0$, it must be $p = c$. At such price both firms 0 and 1 are indifferent between signing a contract or not, since in either case each gets their Cournot-Nash profit, π_0^W for firm 0 and $\pi_1^W - K$ for firm 1. ∎

In the following analysis, we focus on $K \in [\pi_1^V, \pi_1^W)$, the range of K where entry can be strategically deterred by firm 0. Assume w.l.o.g. that when firm 0 is indifferent between deterring or accommodating entry, it chooses to deter entry. Lemma 7 tells us that in any SPNE, if firm 0 strategically deters entry, $p > c$ must hold.

Lemma 7 *For $K \in [\pi_1^V, \pi_1^W)$, in any SPNE if firm 1 stays out, there must be a contract reached in stage one with $p > c$, $x^1 \geq \tau$, such that $(p - c)x^1 = \pi_1^W - K$ is satisfied.*

Proof: By Lemma 4, firms 0 and 1 must have struck a deal with $x^1 \geq \tau$ to have firm 1 stay out. If firm 1 offers $p = c$, firm 1 knows that it will stay out and end up with a zero profit, if it accepts firm 0's offer. However, by rejecting the offer, it will enter and reap $\pi_1^W - K > 0$. Thus it will reject firm 0's offer, a contradiction. Therefore firm 0 must offer $p > c$ to firm 1 to guarantee firm 1 a profit no less than $\pi_1^W - K$, i.e.

$$\Pi_1^{out}(p, x^1) \geq \pi_1^W - K. \tag{4}$$

By Lemma 2 and (2), firm 0's problem under entry deterrence is

$$\max_{p, x^1} \Pi_0^{out}(p, x^1) = \begin{cases} P(M_0)M_0 - cM_0 - (p - c)x^1 & \text{if } x^1 \leq M_0 \\ P(x^1)x^1 - px^1 & \text{if } x^1 \in (M_0, V_0] \end{cases}$$
$$\text{s.t.} \quad x^1 \geq \tau(K)$$
$$(p - c)x^1 \geq \pi_1^W - K$$

If $\tau(K) < M_0$, any combination of $\{p, x^1\}$ satisfying $(p - c)x^1 = \pi_1^W - K$ with $x^1 \in [\tau(K), M_0]$ solves firm 0's problem. Thus in equilibrium when entry is deterred, $p = c + (\pi_1^W - K)/x^1 > c$. Instead, if $\tau(K) \geq M_0$, firm 0's problem is solved at $x^1 = \tau$ and $p = c + (\pi_1^W - K)/\tau > c$. ∎

To be precise, define the function $\underline{p}(x^1) : [\tau(K), M_0] \to R_+$ by

$$\underline{p}(x^1) = c + (\pi_1^W - K)/x^1,$$

12

and define
$$\text{Graph}B \equiv \{(\underline{p}(x^1), x^1)|x^1 \in [\tau(K), M_0]\}.$$

For $\tau(K) > M_0$, define the function $\underline{p}(\tau) : (M_0, V_0] \to R_+$ by

$$\underline{p}(\tau) = c + (\pi_1^W - K)/\tau.$$

Lemma 8 *For $K \in [\pi_1^V, \pi_1^W)$, in any SPNE if firm 1 stays out, it must be $(p, x^1) \in$ Graph B for $\tau(K) \leq M_0$, and $(p, x^1) = (\underline{p}(\tau), \tau)$ for $\tau > M_0$. Total profits for firms 0 and 1 are*

$$\Pi_0^{out}(\tau) = \begin{cases} P(M_0)M_0 - cM_0 - \pi_1^W + K & \text{if } \ \tau \leq M_0 \\ P(\tau)\tau - c\tau - \pi_1^W + K & \text{o.w.} \end{cases}$$
$$\Pi_1^{out}(\tau) = \pi_1^W - K$$

Proof: It follows Lemma 2, Lemma 7, the definitions of Graph B and $\underline{p}(\tau)$. ∎

3.2 Major Result

For $K \geq \pi_1^W$, *entry is blockaded*, and firm 1 is symmetric to any of firms 2,...,n. At the competitive price $p = c$, firm 0 is indifferent between ordering its monopoly quantity M_0 from any of them. For $K < \pi_1^V$, *entry can not be deterred*. Sourcing to firm 1 is no longer a viable enter-deterring strategy for firm 0: any $x^1 > V_0$ is incredible to firm 1 as firm 0's future quantity of good F, and any $x^1 < V_0$ is not large enough to drive down firm 1's post-entry profit to zero. In our model, by no means can firm 0 deter firm 1's entry.

The following analysis focuses on when K is in the middle range, i.e. $K \in [\pi_1^V, \pi_1^W)$. Firm 0 can always successfully deter entry by offering to purchase $\tau(K)$ units under a large enough price p, to give firm 1 enough lure to accept the offer and stay out. By Lemma 7, $p > c$ must incur to achieve such a goal. Thus for each unit of good I it orders from firm 1, firm 0 incurs $p - c > 0$ amount of extra cost compared to ordering from firm 2. There is a trade off for firm 0 between its monopoly status and the burden incurred by deterring entry. If under some circumstances it is too costly for firm 0 to deter entry so that it would rather let entry occur, we call it as *entry is accommodated*.

Define
$$K^M \equiv \{K|\tau(K) = M_0\}.$$

It is true that $K^M < \pi_1^W$, since $M_0 > W_0$, and $\tau(K)$ is strictly decreasing in K. From firm 0's respect, it can always set $x^1 = 0$ to have its Cournot-Nash profit π_0^W (by Lemma 6). By Lemma 8, it will engage in entry deterrence only if

$$\Pi_0^{out}(\tau) \geq \pi_0^W, \tag{5}$$

which implies:

(i) If $K \geq K^M$, i.e. $\tau(K) \leq M_0$, entry deterrence requires

$$[P(M_0) - c]M_0 \geq \pi_0^W + \pi_1^W - K \qquad (6)$$

This condition is always satisfied since $[P(M_0) - c]M_0 > \pi_0^W + \pi_1^W$ is true.

(ii) If $K < K^M$, i.e. $\tau(K) > M_0$, entry deterrence requires

$$[P(\tau) - c]\tau \geq \pi_0^W + \pi_1^W - K. \qquad (7)$$

The left-hand-side of Condition (7) is strictly increasing in K, since $P'\tau + P - c < 0$ is true for $\tau > M_0$:

$$\frac{d[P(\tau)\tau - c\tau]}{dK} = (P'\tau + P - c)\frac{d\tau}{dK} > 0.$$

Its right-hand-side strictly decreases in K. There exists a unique K which equates these two sides. Denote it as $\bar{K}$ and define it by

$$\bar{K} \equiv \{K | [P(\tau(K)) - c]\tau(K) = \pi_0^W + \pi_1^W - K\}.$$

If (7) is violated at $K = \pi_1^V$ (at which $\tau(K) = V_0$), we have that $\bar{K} \in (\pi_1^V, K^M)$; otherwise $\bar{K} < \pi_1^V$ and Condition (7) is always satisfied for $K < K^M$.

Our major result for game Γ is depicted by the following theorem, also illustrated by Figure 4.

Figure 4: SPNE of Game Γ

Theorem 1 *There exists SPNE for game Γ.*
(I) If $K \geq \pi_1^W$, entry is blockaded. In any SPNE, either $x^1 \in (0, M_0]$ at $p = c$, or no contract reached between firms 0 and 1. Moreover, $d_1 = 0, x^2 = M_0 - x^1, q_0 = M_0$.
(II) If $K \in [K^M, \pi_1^W)$, entry is strategically deterred. In any SPNE, $(p, x^1) \in$ Graph B, with $d_1 = 0, x^2 = M_0 - x^1, q_0 = M_0$.
(III) If $K \in [\pi_1^V, K^M)$, there are two subcases:
    (IIIa) If $K \geq \bar{K}$, entry is strategically deterred. The unique SPNE is depicted by $(p, x^1) = (\underline{p}(\tau), \tau), d_1 = 0, x^2 = 0, q_0 = \tau$.

14

(IIIb) If $K < \bar{K}$, entry is accommodated. In any SPNE, either $x^1 \in (0, W_0]$ at $p = c$, or no contract reached between firms 0 and 1. Moreover, $d_1 = 1, x^2 = W_0 - x^1, q_0 = W_0, q_1 = W_1$.
(IV) If $K < \pi_1^V$, entry can not be deterred. In any SPNE, either $x^1 \in (0, W_0]$ at $p = c$, or no contract reached between firms 0 and 1. Moreover, $d_1 = 1, x^2 = W_0 - x^1, q_0 = W_0, q_1 = W_1$.

Proof: Proof to (I) and (IV) follows easily from Lemma 4 and Lemma 6.

Proof to (II), (III). Firstly, notice that (6) and (7) are necessary conditions for entry to be strategically deterred in SPNE. Secondly, we show that they are also sufficient. When they are satisfied, (5) is true, implying that firm 0's optimal profit in deterring entry is larger than its optimal profit when entry occurs. Firm 0 will not deviate to allowing entry. On the other side, by Lemma 8, firm 1 gets $(p - c)x^1 = \pi_1^W - K$ by accepting firm 0's offer. By Lemma 6, firm 1 has no incentive to deviate to rejecting the offer and entering for good F. The rest part of (II) and (IIIa) follows immediately. Thirdly, when $K < \bar{K}$, Condition (7) is violated. There does not exist any $p > c$ at which $x^1 \geq \tau$ can leave both firms 0 and 1 no worse off than they would be under entry. Firm 0 foresees entry and will accommodate it. The rest part of (IIIb) follows Lemma 6. Lastly, we show that there does not exist any SPNE other than what stated by (II) and (III) in the theorem. This simply follows Lemma 6, Lemma 7, and Lemma 8. ∎

The pure reason for firm 0 to source to firm 1 at $p > c$ is to deter its entry. Moreover, if $K > K^M$, firm 0 will also source to firm 2 with $x^2 = M_0 - x^1$, whenever $x^1 < M_0$. The following corollary is straightforward.

Corollary 1 *In any SPNE, when entry is strategically deterred, firm 0 sources also to firm 2 only if $K > K^M$.*

Requiring firm 0's threat of a predatory amount upon entry to be credible makes entry deterrence harder. When $\pi_1^V > \bar{K}$, such a restriction increases the lower bound of K (from $\bar{K}$ to π_1^V) at which entry can be deterred. For $K \in (\bar{K}, \pi_1^V]$, it is still true that deterring entry can create a positive surplus for both firm 0 and firm 1. However, entry can not be deterred, because the least quantity of firm 0 which is large enough to make firm 1's entry unprofitable is no longer credible to firm 1.

3.3 When Firm 1 Is Setting $\{p, x^1\}$ In Stage One

In the SPNE of game Γ, whenever a deal is struck between firms 0 and 1 in stage one, it must be that none of them is worse off compared to without a deal. The nature of entry deterrence in our model is collusive. We would expect that major conclusions of game Γ will be kept intact if firm 1 is the one who offers price and/or quantity to firm 0. For example, modify game Γ in a way that in stage one firm 1 offers $\{p, x^1\}$ then firm 0 decides to accept it or not. Denote the modified game as Γ_1.

It is clear that whenever entry is blockaded or entry can not be deterred, nothing will change in the SPNE of game Γ_1 compared to game Γ. We focus on when $K \in [\pi_1^V, \pi_1^W)$.

Again firm 1 will stay out if and only if $x^1 \geq \tau(K)$. Suppose that having entry deterred is better off to both firms 0 and 1. If $\tau(K) \geq M_0$, firm 1 will offer $x^1 = \tau(K)$, since $x^1 < \tau(K)$ is not enough to keep firm 1 out, whereas $x^1 > \tau(K)$ decreases the total profit from the market of good F, which is the amount they share through their transaction on good I. To maximize firm 1's share, firm 1 will offer $p = P(\tau) + \pi_0^W / \tau$, the highest price firm 0 will accept. Notice that only when $K \geq \bar{K}$ will firms 0 and 1 strike a deal, since $x^1 = \tau(K)$ is still true whenever firm 1 wants to have its entry deterred by firm 0. If $\tau(K) < M_0$, firm 1's problem is

$$\max_{p,x^1}(p - c)x^1$$
$$\text{s.t. } x^1 \geq \tau(K)$$
$$P(M_0)M_0 - c(M_0 - x^1) - px^1 \geq \pi_0^W$$

Any combination of $\{p, x^1\}$ satisfying $(p - c)x^1 = P(M_0)M_0 - cM_0 - \pi_0^W$ and $x^1 \geq \tau(K)$ do the job.

Define the function $\bar{p}(x^1) : [\tau(K), M_0] \to R_+$ by

$$\bar{p}(x^1) = c + [(P(M_0) - c)M_0 - \pi_0^W]/x^1,$$

and define

$$\text{Graph}\bar{B} \equiv \{(\bar{p}(x^1), x^1)|x^1 \in [\tau(K), M_0]\}.$$

For $\tau(K) > M_0$, define the function $\bar{p}(\tau) : (M_0, V_0] \to R_+$ by

$$\bar{p}(\tau) = P(\tau) + \pi_0^W / \tau.$$

We have a proposition below.

Proposition 1 *The SPNE depicted by Theorem 1 is kept the same for Γ_1, except that when entry is strategically deterred, it is $(p, x^1) \in$ Graph $\bar{B}$ in (II) and $(p, x^1) = (\bar{p}(\tau), \tau)$ in (III)a.* $\qquad\square$

Note that when entry is deterred, $p > c, x^1 \geq \tau$ holds. The pure purpose of firm 0 to accept firm 1's offer is still to deter entry. However, with firm 1 the one who decides their sourcing contract, the whole surplus from entry deterrence is reaped by firm 1.

3.4 A Linear Example

To establish more precise conclusions, consider an example with the market demand for good F given by $P = \max\{0, a - Q\}$, with $a > c > 0, Q = q_0 + q_1$. The following values are easily calculated:

$$M_0 = \frac{a - c}{2}; \quad W_0 = W_1 = \frac{a - c}{3}, \pi_0^W = \pi_1^W = \frac{(a - c)^2}{9};$$

$$V_0 = \begin{cases} \frac{a+c}{3} & \text{if } c < \frac{a}{2} \\ \frac{a}{2} & \text{o.w.} \end{cases} \qquad V_1 = \begin{cases} \frac{a-2c}{3} & \text{if } c < \frac{a}{2} \\ 0 & \text{o.w.} \end{cases}$$

$$\pi_0^V = \begin{cases} \frac{(a+c)(a-2c)}{9} & \text{if } c < \frac{a}{2} \\ \frac{a(a-2c)}{4} & \text{o.w.} \end{cases} \qquad \pi_1^V = \begin{cases} \frac{(a-2c)^2}{9} & \text{if } c < \frac{a}{2} \\ 0 & \text{o.w.} \end{cases}$$

If $K \geq \pi_1^W$, entry is blockaded; if $K < \pi_1^V$, entry can not be deterred. The following analysis focuses on $K \in [\pi_1^V, \pi_1^W)$, where entry may be strategically deterred.

Given p and $x^1 \in (W_0, V_0]$, firm 1 will stay out if and only if

$$(a - x^1 - q_1^f(x^1))q_1^f(x^1) - cq_1^f(x^1) \leq K,$$

which gives the threshold of x^1 as

$$\tau = a - c - 2\sqrt{K}.$$

Solving $\tau = M_0$ gives $K^M = \frac{(a-c)^2}{16}$.
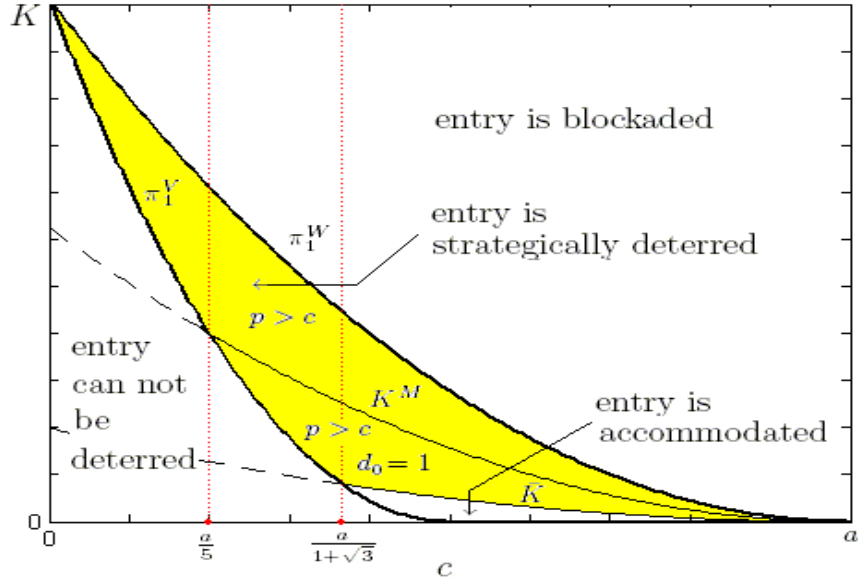
Figure 5: The linear example

There exists two cases: either $M_0 < V_0$ or $M_0 \geq V_0$. Equivalently, they are $c > \frac{a}{5}$ or $c \leq \frac{a}{5}$. We will analyze them separately.

Case i. $c > \frac{a}{5}$. This implies that $M_0 < V_0$. For $K \geq K^M$, entry is deterred in any SPNE. For $K < K^M$, Condition (7) is rewritten as

$$\frac{1}{9}(a^2 - 2ac - 2c^2) \geq \pi_0^W + \pi_1^W - K.$$

Values of a satisfying this inequality is found as $a > (1+\sqrt{3})c$. There are two subcases.

17

Subcase i. $c \le \frac{a}{1+\sqrt{3}}$. Entry is always strategically deterred.

Subcase ii. $c > \frac{a}{1+\sqrt{3}}$. At $K = K^V$, it is true that $P(V_0)V_0 - cV_0 < \pi_0^W + \pi_1^W - K$. There exists $\bar{K} > K^V$ which by Condition (7) is solved as

$$\bar{K} = \frac{2}{27}(2 - \sqrt{3})(a - c)^2.$$

For $K \le \bar{K}$, entry is accommodated. Firm 0 will source to firm 2 in order to have the lowest possible cost in their standard Cournot competition. Instead, for $K > \bar{K}$, entry is strategically deterred.

For $K \le K^M$, firm 0 sources solely to firm 1 with $x^1 = \tau(K)$, then produces $q_0 = \tau(K) \ge M_0$ for good F. Firm 1 sources to a high-price provider and produces more than its monopoly quantity, in order to deter firm 1's entry. When $\tau(K) > M_0$, $q_0 = M_0$ is optimal for firm 1, and it will expand the entry-deterring quantity $x^1 = \tau(K)$ by sourcing either to firm 1 or firm 2.

Case ii. $c \le \frac{a}{5}$, i.e. $M_0 \ge V_0$. Entry is always deterred. Moreover, $K \ge K^M$ holds. When $K > K^M$, firm 0 may source to both firm 1 and firm 2, with total quantity for good F given by $q_0 = M_0$.

Entry becomes impossible to be deterred for $K < K^V$. For any given value of K, this implies that the value of c is relatively small compared with the market size, so that even if firm 1 is competing a firm who has zero marginal cost, entry is still profitable for firm 1. Conclusions of this example are shown by Figure 5.

3.5 Social Welfare Analysis

In this section we investigate the impact on social welfare of strategic sourcing which deters firm 1's entry, where social welfare is measured as the summation of consumer's surplus and firms' profits.

For $K \ge \pi_1^W$ or K smaller than $\max\{\pi_1^V, \bar{K}\}$, firm 0 may order good I from firm 1, but that has no distortion on the social welfare. The range of K matters to our analysis is $K \in [\max\{\pi_1^V, \bar{K}\}, \pi_1^W)$, in which entry is strategically deterred through firm 0's sourcing to firm 1. For K in this range, if firm 1 is not providing good I at all, the unique equilibrium is that firm 1 enters and Cournot quantity $W_0 + W_1$ is produced for good F. Take this as the benchmark case. Social welfare is

$$W^C = \int_0^{W_0+W_1} [P(q) - c]dq - K$$

in the benchmark case. When there is strategic sourcing leading to entry deterrence, social warfare is

$$W^\tau = \int_0^{\max\{M_0, \tau(K)\}} [P(q) - c]dq.$$

Thus

$$W^\tau - W^C = K - \int_{\max\{M_0, \tau(K)\}}^{W_0+W_1} [P(q) - c]dq$$

18

measures the distortion of strategic sourcing on social welfare. Define

$$A(K) \equiv \int_{\max\{M_0, \tau(K)\}}^{W_0+W_1} [P(q) - c]dq.$$

$A(K)$ measures the society's loss due to strategic sourcing, net of the saving of K. It is strictly increasing in K for $K < K^M$ and becomes a constant thereafter. The relationship of $A(K)$ and K is shown in Figure 6.

Proposition 2 *Entry-deterring strategic sourcing from firm 0 to firm 1 strictly improves social welfare when $K > \int_{\max\{M_0, \tau(K)\}}^{W_0+W_1}[P(q) - c]dq$.* $\qquad\square$

There are two effects of strategic sourcing on social welfare. The first one is its impact on firms' profits through the saving of K and the distortion on selling of good F. Since strategic sourcing exists only when both firms agree with their sourcing contract, it is clear that each firm must get no less than what it can have without strategic sourcing. The first effect improves social welfare. The second one is the change of consumers' welfare, which can be negative or positive, solely depending on the quantity produced of good F. If $\tau(K)$ which firm 0 sources is so large that $\tau(K) > W_0 + W_1$, the Cournot-Nash quantity when it accommodates entry, consumers' welfare can also improve.
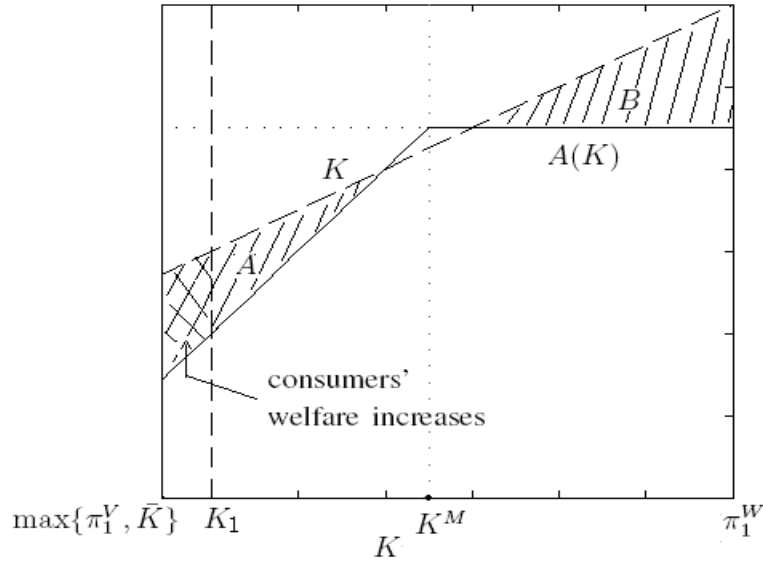

Figure 6: Social Welfare Effect of Strategic Sourcing

Area A and B in Figure 6 give the regime in which strategic sourcing which deters entry strictly improves social welfare. In area A, the value of K is so small that to deter entry, firm 0 has to source $\tau(K)$ close to or even larger than the duopoly quantity. The upshot is, either the second effect is negative but small so is dominated by the first effect, or even the second effect is positive. Denote $K_1 \equiv \{K|\tau(K) = W_0 + W_1\}$. The

19

area in A with $K < K_1$ has not only both firms better off, but also consumers' welfare improved due to a larger quantity sold for good F than the duopoly quantity. Instead, in area B, K is large so that firms save a lot by deterring an inefficient entry, whereas quantity produced for good F is $M_0 < W_0 + W_1$, thus consumers are strictly worse off. The first effect dominates the second effect hence social welfare is higher.

Consider the linear demand case $P = \max\{0, a - Q\}$ with $a > c > 0, Q = q_0 + q_1$. Recall that $\pi_1^W = \frac{(a-c)^2}{9} > \bar{K} = \frac{2}{27}(2 - \sqrt{3})(a - c)^2$, $\pi_1^V = \frac{(a-2c)^2}{9}$ for $c < \frac{a}{2}$ and 0 otherwise. For $K \geq K^M = \frac{(a-c)^2}{16}$, $A(K) = \int_{M_0}^{W_0+W_1}[P(q) - c]dq = \frac{5}{72}(a - c)^2$. Thus when $K \in (\frac{5}{72}(a - c)^2, \frac{(a-c)^2}{9})$, sourcing between firms 0 and 1 which deters firm 1's entry is social welfare improving. On the other hand, when $K \in [\max\{\pi_1^V, \bar{K}\}, K^M)$, $A(K)$ intersects K at $K = \frac{(a-c)^2}{18}$. Social welfare is also improved for $K \in [\max\{\pi_1^V, \bar{K}\}, \frac{(a-c)^2}{18})$. Moreover, with K_1 calculated as $\frac{(a-c)^2}{36}$, consumers' welfare increases under strategic sourcing for $K \in [\max\{\pi_1^V, \bar{K}\}, K_1)$.

4 When Good I Is Ordered in Stage One

In the basic model, we assume that after firm 1's entry decision, firm 0 can expand x^1 by ordering more of good I from firm 2. A different timing worthy to be investigated is when firm 0 must order all its demand on good I in stage one. This models situation, for example, when transportation of good I requires time, so that firm 0 has to order good I ahead of the final product competition with a certain period.

We modify the timing of Γ as the following: There are still three stages. In stage one, firm 0 makes a take-it-or-leave-it offer $\{p, x^1\}$ to firm 1, then firm 1 decides either to accept or reject. After observing firm 1's decision, firm 0 orders quantity x^2 from the competitive market. In stage two, firm 1 decides to enter or stay out. If it enters, in stage three, firms 0 and 1 determines quantities q_0, q_1 for good F, otherwise firm 0 decide q_0 along. Note that firm 1 can not observe the value of x^2 either prior to or post to its entry.

Denote the modified game as Γ_2. Solution concept for Γ_2 is sequential equilibrium, denoted simply as equilibrium for this section.

With $K \geq \pi_1^W$, firm 0 is indifferent between ordering M_0 units of good I from any of firms 2,..,n at the competitive price. With $K < \pi_1^V$, $x^1 > V_0$ is not credible to firm 1 as firm 0's post-entry quantity therefore entry can not be deterred. Similar as in the benchmark model, entry is blockaded if $K \geq \pi_1^W$ and always happens if $K < \pi_1^V$. Our following analysis focus on when $K \in [\pi_1^V, \pi_1^W)$.

4.1 If Firm 1 Is Not Providing I

We firstly consider the simplified case when firm 1 is out of the market of good I. Firm 1 knows that firm 0 orders from firm 2, but can not observe the value of x^2.

Lemma 9 *For $K \in [\pi_1^V, K^M)$, a unique sequential equilibrium exists: $x^2 = q_0 = W_0$; firm 1 believes $x^2 = W_0$, then enters to produce $q_1 = W_1$. Equilibrium profits are π_0^W for firm 0 and $\pi_1^W - K$ for firm 1.*

Proof: Firstly, we show the strategies and belief above constitute an equilibrium. Given firm 1's belief, its optimal strategy is to enter and produce $q_1 = W_1$; given firm 1's strategy, firm 0 is optimal producing $q_0 = W_0$, thus it should source $x^2 = W_0$.

Secondly, we show that there does not exist any other equilibrium. For $K \in [\pi_1^V, K^M)$, we have $\tau(K) \in (M_0, V_0]$. Suppose that firm 1 believes that firm 0 has sourced $x^2 \geq \tau(K)$ hence stays out. However, given firm 1's strategy, firm 0 should source only $x^2 = M_0$, to reap its monopoly profit. Thus firm 1 should not believe that firm 0 is deterring entry, and it should enter. Given that firm 1 enters, the only intersection of their reaction functions in the final-product market is point W, at which each has no incentive to deviate. Hence the strategies together with firm 1's belief specified by the lemma is the unique equilibrium. ∎

Lemma 10 *For $K \in [K^M, \pi_1^W)$, when there is no outsourcing between firms 0 and 1, two pure strategy equilibria exist:*
i. $x^2 = q_0 = W_0$; firm 1 believes $x^2 = W_0$, then enters to produce $q_1 = W_1$. Equilibrium profits are π_0^W for firm 0 and $\pi_1^W - K$ for firm 1;
ii. $x^2 = q_0 = M_0$; firm 1 believes $x^2 = M_0$, then stays out. Equilibrium profits are π_0^M for firm 0 and zero for firm 1.
There is also one mixed strategy equilibrium:
iii. $x^2 = W_0$ with probability θ^* and $x^2 = M_0$ with probability $1 - \theta^*$; firm 1 believes in $(\theta^*, 1-\theta^*)$, and enters to produce $q_1 = W_1$ with probability γ^*, stays out with probability $1 - \gamma^*$, with $\theta^*, \gamma^* \in (0, 1)$. Firm 1's expected profit is zero.

Proof: It is easy to see that i, ii constitute two pure strategy equilibria and there does not exist other pure strategy equilibrium. Firm 0 chooses between $x^2 = W_0$ and $x^2 = M_0$; firm 1 chooses between entering or staying out. If firm 0 is accommodating entry yet firm 1 stays out, the outcome is that firm 0 is a monopolist which produces $q_0 = W_0$. Instead, if firm 0 is deterring entry yet firm 1 enters, firm 0 will produce $q_0^x \equiv \min\{M_0, V_0\}$, since its reaction function in stage three is OO'. Total payoff for each firm is given below:

0 / 1	(γ) Enter	$(1 - \gamma)$ Stays out
$(\theta)\ W_0$	$\pi_0^W, \pi_1^W - K$	$[P(W_0) - c]W_0, 0$
$(1 - \theta)\ M_0$	$[P(q_0^x + W_1) - c]q_0^x, [P(q_0^x + W_1) - c]W_1 - K$	$[P(M_0) - c]M_0, 0$

For firm 0, given that firm 1 enters, $\pi_0^W = [P(W_0 + W_1) - c]W_0 > [P(q_0^x + W_1) - c]q_0^x$ since $M_0 > W_0, V_0 > W_0$ holds; given that firm 1 stays out, $[P(M_0) - c]M_0 > [P(W_0) - c]W_0$. For firm 1, given that $q_0 = W_0$, $\pi_1^W - K > 0$; given that $q_0 = M_0$, $[P(q_1^x + W_1) - c]W_1 - K < 0$. The reason for the second inequality is, if $q_0^x = M_0$,

then $[P(M_0 + W_1) - c]W_1 < [P(M_0 + M_1) - c]M_1 \leq K$ since $K \geq K^M$; if $q_0^x = V_0$, then $[P(V_0 + W_1) - c]W_1 < [P(V_0 + V_1) - c]V_1 < K$ since $K > \pi_1^V$. There must exist a mixed strategy equilibrium, with firm 1's expected profit being zero. ∎

4.2 If Firm 1 Is Providing I

Now we back to game Γ_2. Through our analysis above, if firm 1 chooses to stay out of the market for good I, its equilibrium profit is either $\pi_1^W - K$ or zero. This gives the intuition that the entry decision in equilibrium should be the same as in game Γ, since firm 1 can guarantee itself no more than $\pi_1^W - K$ by rejecting firm 0's offer. We have a lemma below.

Lemma 11 *For $K \in [\pi_1^V, \pi_1^W)$, in any equilibrium, if $K \geq K^M$, entry is strategically deterred; if $K < K^M$, entry is strategically deterred as long as Condition (7) holds, and is accommodated otherwise.*

Proof: The total profit under entry in equilibrium is still $\pi_0^W + \pi_1^W - K$, and through sourcing $x^1 \geq \tau$ firm 0 can have entry deterred. If $K \geq K^M$, Condition (6) is required for entry deterrence but it is always true; if $K < K^M$, the condition for entry-deterrence to be profitable compared with the total profit under entry is given by (7). ∎

Proposition 3 *The equilibrium entry decision for Γ is robust for Γ_2. I.e. firm 1 enters only when $K < \max\{\pi_1^V, \bar{K}\}$.*

Proof: It is straightforward since Condition (7) is satisfied when $K \geq \bar{K}$. ∎

5 When Post Entry Competition Is à la Bertrand

It is interesting to investigate what if the post entry competition between firms 1 and 2 is à la Bertrand rather than Cournot. For this section, we assume that if firm 1 enters, firms 0 and 1 produce differentiated good F. They compete by setting prices r_0, r_1 for good F, respectively. Assume demand functions for firms 0 and 1 are $q_0(r_0, r_1)$ and $q_1(r_0, r_1)$ in stage three. We impose all standard assumptions on the demand functions, including that self-effect dominates cross-effect, reaction functions be upward sloping, so that there exists a unique interior solution for their competition. Denote this game as Γ_B.

Firms 0 and 1's reaction functions in the post-entry game are illustrated by Figure 7. RR' is firm 1's reaction curve after its entry. For firm 0, there are two reference lines: OO' is its reaction curve with marginal cost zero, and MM' is its reaction curve with marginal cost c. If firm 0 sources $x^1 > 0$ in stage two, its reaction function is kinked and connecting OO' to MM', with the part between given by $q_0(r_0, r_1) = x^1$. When x^1 increases, $q_0(r_0, r_1) = x^1$ shifts up, therefore the intersection of firms 0 and 1's reaction functions shifts along WV to the left. By manipulating x^1, firm 0 can have any
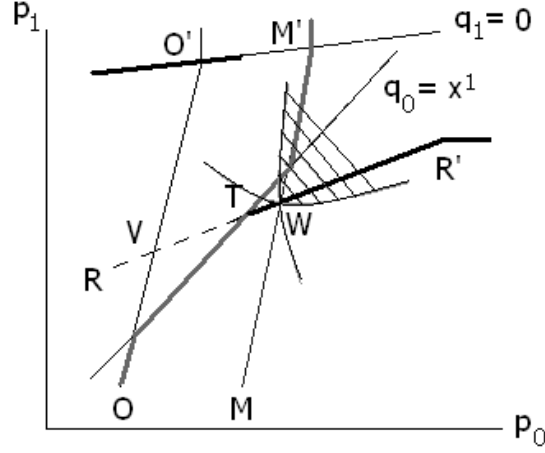
Figure 7: Reaction functions in Bertrand competition

point along segment WV as the post-entry equilibrium, thus is again granted a limited leadership along segment WV.

With a positive entry cost K, firm 1's reaction function is kinked at point T, then coincides with the curve $q_1(r_0, r_1) = 0$. Firm 1's optimal strategy is to stay out if $r_0 \leq T_0$. On firm 0's side, by sourcing x^1 big enough, it can convince firm 1 that its future price satisfies $r_0 \leq T_0$ as long as point T is on segment WV, therefore successfully have entry deterred. Denote firm $i, i = 0, 1$'s profit at point W, V as ξ_i^W, ξ_i^V respectively. Similar as in Cournot competition, entry is blockaded for $K \geq \xi_1^W$ and can not be deterred for $K < \xi_1^V$. For $K \in [\xi_1^V, \xi_1^W)$, sourcing a large enough quantity from firm 0 to firm 1 can again deter entry. We will then focus on this range of K.

If firm 1 stays out in any SPNE, it must be that firm 0 sources a positive quantity to firm 1 under $p > c$. Instead, if firm 1 enters in any SPNE, no sourcing can occur between firms 0 and 1 with $p > c$. The first statement is clear since firm 0 must remedy firm 1's loss by staying out. For the second statement, notice that under entry, their competition yields point W as the equilibrium (the hatched area in Figure 7 shows Poretal improvement from point W for both firms), whether sourcing happens between firms 0 and 1 or not. With firm 1's entry expected in stage one, if $p > c$, firm 0 is unwilling to source to firm 1; if $p < c$, firm 1 is unwilling to provide. Only at $p = c$ it is possible for an sourcing contract to be signed followed by firm 1's entry. Firms 0 and 1's profits are ξ_0^W and $\xi_1^W - K$ whether $x^1 > 0$ or not.

Denote the threshold of x^1 which makes firm 1 to be indifferent between entering or not as τ^B. Let ξ_i represent profit for firm $i, i = 0, 1$ when the post-entry game follows Bertrand competition. The necessary and sufficient condition for entry to be deterred is

$$[q_0^{-1}(\tau^B) - c]\tau^B \geq \xi_0^W + \xi_1^W - K,$$

which gives the threshold of K denoted as $\bar{K}^B$, such that entry is strategically deterred as long as $K \in [\max\{\xi_1^V, \bar{K}^B\}, \xi_1^W)$. In fact, since Bertrand competition is harsher than

23

Cournot competition and leads to lower duopoly profit, firm 0 have higher incentive to deter entry and firm 1 has less incentive to entry. We expect that there should be less entry with Bertrand competition.

Consider a numerical example. Suppose market demand for good F is

$$q_i = \begin{cases} 10 - r_i + \frac{1}{2}r_j & \text{if } r_j < 10 + \frac{r_i}{2} \\ 15 - \frac{3}{4}r_i & \text{o.w.} \end{cases} \quad i, j = 0, 1, i \neq j$$

Let $c = 7, K = 16$. Without entry threat, firm 0's monopoly price and profit when its marginal cost is c are $r_0^M = \frac{27}{2}$ and $\xi^M = \frac{507}{16}$. If firm 0 accommodates entry, the Bertrand equilibrium prices are $W_0^B = W_1^B = \frac{34}{3}$, profits are $\xi_0^W = \xi_1^W = \frac{169}{9}$. Thus firm 1's net profit upon entry is $\xi_1^W - K = \frac{25}{9}$ in equilibrium.

Suppose firm 0 is deterring entry. Given $x^1 > 0$ and firm 0's reaction function intersects RR' between W and V, then firm 0 is going to charge price which solves

$$q_0(r_0, r_1) = x^1$$

for a given r_1. Denote the solution as $r_0(x^1, r_1)$. Firm 1 solves

$$\max_{r_1}[(r_1 - c)(10 - r_1 + \frac{r_0(x^1, r_1)}{2})],$$

which is strictly concave in r_1. Denote the solution as $r_1^f(x^1)$, and the corresponding equilibrium r_0 as $r_0^l(x^1)$. The value of τ^B is thus solved by

$$[r_1^f(x^1) - c]q_1(r_0^l(x^1), r_1^f(x^1)) = K.$$

In this example $\tau^B = \frac{11}{2}$.

Since firm 0's profit is decreasing from point W to V, it will set $x^1 = \tau^B$ when deterring entry. Notice that firm 0 will not source to firm 2, since the price r_0 solved by $\tau^B = 15 - \frac{3}{4}r_0$ is $r_0^\tau = \frac{38}{3} < r_0^M$. Its optimal profit with $x^1 = \tau^B$ is $\xi_0^{det} = (r_0^\tau - p)\tau^B$.

The incentive compatibility condition for firm 0 to engage in entry deterrence is $\xi_0^{deter} \geq \xi_0^W$. By letting these two sides equal, we have that the highest p for firm 0 to deter entry is $\bar{p} = \frac{916}{99}$. On the other side, firm 1's incentive compatibility condition for staying out is $\xi_1^{out} = (p - c)\tau^B > \xi_1^W - K$. At $p = \bar{p}$, we have that $\xi_1^\tau = \frac{223}{18} > \frac{25}{9}$. The SPNE is, firm 1 charges $p = \bar{p}$ in stage one. In stage two, $x^1 = \tau^B$, then firm 1 stays out. In stage three, firm 0 is a monopolist which sells τ^B at price $r_0 = \frac{38}{3}$.

By converting the system of demand functions into inverse demand functions,

$$p_i = 20 - \frac{4}{3}q_i - \frac{2}{3}q_j, \quad i, j = 0, 1, i \neq j,$$

we solve the game when post entry rule is Cournot competition. Figure 8 compares the equilibrium outcome with Cournot competition and Bertrand competition. Since $\max\{\xi_1^V, \bar{K}^B\}$ lies below $\max\{\pi_1^V, \bar{K}\}$ for each value of c, there is less entry with Bertrand competition.
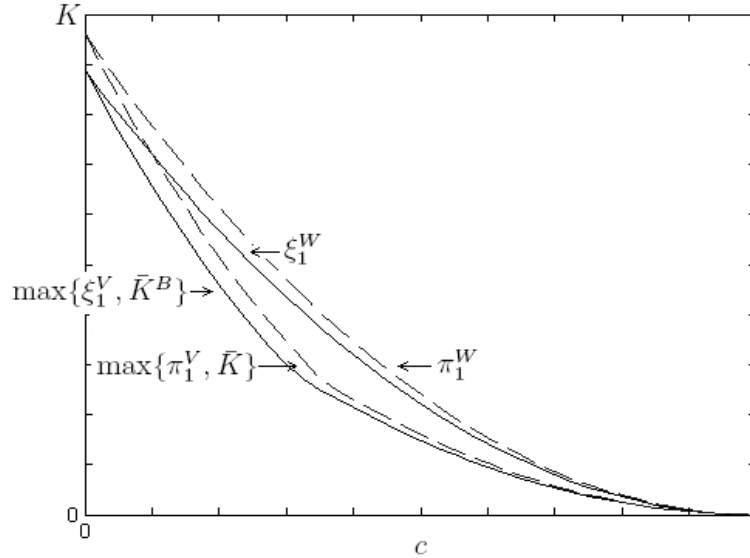
Figure 8: Equilibrium outcome: Cournot vs. Bertrand

6 When There Are Economies of Scale for Producing I

Two reasons make strategic sourcing when economies of scale prevail for producing good I be interesting. The first reason is practical. Our model applies to the world-wide outsourcing, and one important incentive for outsourcing is to pursue economies of scale. The second reason is, the existence of economies of scale incurs complicated strategic consideration, which may make our former prediction ambiguous.

Under economies of scale, firm 1 has incentive to attract firm 0's order if it is going to enter in spite of the follower's disadvantage, because the units it produces for firm 0 helps to decrease its future production cost. On the other side, firm 0 will be cautious about sourcing to firm 1, since by doing so, firm 1 may be seduced to enter as an entrenched competitor of good F. When such a consideration dominates, firm 0 may no longer source to firm 1. In this case, it must be that firm 0 orders solely from one firm out of firms 2,...,n to utilize economies of scale.

However, we find that the basic argument for the benchmark game applies here with economies of scale, leaving the qualitative part of our major conclusion intact. Under quite general assumptions, the lure for firm 0 to source to firm 1 in order to deter entry is well preserved, which may dominates other strategic considerations and lead to a sourcing contract between firms 0 and 1.

Suppose firms $1, ..., n$'s production cost $C(q)$ for good I satisfies $C'(q) > 0, C''(q) < 0$ for ant unit of $q \geq 0$. To guarantee the existence and uniqueness of a pure-strategy Nash equilibrium between firms 0 and 1 after firm 1's entry, assume

$$P''(Q)q_1 + P' - C'' < 0, \tag{8}$$

where $Q = q_0 + q_1$. Condition (8) requires that the cost concavity for good I can not be too large. As an example, consider the case with linear demand $P(Q) = \max\{0, a - Q\}$ and quadratic cost $C(q) = cq - vq^2$. Then Condition (8) implies that $v < \frac{1}{2}$. Moreover, let the price of good I required by firms $2, ..., n$ as $p_2, ..., p_n$ in stage three. All other issues are kept the same as in the baseline model.

The validity of strategic sourcing aimed at entry-deterrence is well kept. To see this, note if x^1 is large but not too large, firm 1 knows that after its entry firm 0's quantity of good F is given by x^1. The reason is, on the one side, ordering a little bit more from any other provider entails a high price for firm 0 hence is not profitable; on the other side firm 0 has no incentive to leave any of x^1 unused since its cost is sunk. Thus firm 1's optimal choice is to accommodate the value of x^1 by producing the follower's quantity upon its entry. Its optimal profit after entry is

$$\pi_1^f(x^1) = P(x^1 + q_1^f(x^1))q_1^f(x_1) - C(x^1 + q_1^f(x^1)).$$

By envelope theorem,

$$\frac{d\pi_1^f(x^1)}{dx^1} = P'q_1^f(x_1) - C' < 0.$$

Again it is possible for firm 0 to drive down firm 1's post-entry profit to zero through sourcing to it a large enough quantity.

Moreover, having firm 1 stay out with a constructed buyer-seller relationship can be profitable for both firms 0 and 1. The argument is as follows. When firm 0 is a monopolist, the profit it can reap from the market of good F is bigger than the total profit of duopolists, even if firm 1 supplies firm 0 with a decreasing average cost. In this case, firms 0 and 1 can find an appropriate price at which the payment from firm 0 to firm 1 is enough to remedy firm 1's loss by staying out, and at the same time leave firm 0 no worse off than in a duopoly market.

To have a closed-form solution under economies of scale, assume the market demand for good F and the marginal cost for good I are both linear. More precisely, assume $P(Q) = \max\{0, a - Q\}$, production cost of good I is

$$C(q) = \begin{cases} cq - vq^2 & \text{for } q \leq \dfrac{c}{2v} \\[2mm] \dfrac{c^2}{4v} & \text{for } q > \dfrac{c}{2v} \end{cases}$$

Assume the parameters satisfy

$$0 < c < a \leq \frac{c}{2v}. \tag{9}$$

The last inequality of Condition (9) guarantees that in equilibrium, any quantity for good F produced by firm 1 entails positive marginal cost. Notice that $v < \frac{1}{2}$ by (9). Timing of the game is the same as game Γ. Denote the new game as $\Gamma(a, c, v)$.

Define

$$\pi_1^W \equiv \frac{(1-v)^3(a-c)^2}{(3-6v+2v^2)^2}, \quad \pi_1^V \equiv (1-v)[\frac{(1+2v)a-2c}{3-2v}]^2;$$

$$\tau(K) \equiv \frac{a-c-2\sqrt{K(1-v)}}{1-2v}, \quad M_0 \equiv \frac{a-c}{2(1-v)}, \quad \tilde{x}^1 = \frac{(1-2v)(a-c)}{3-2v}.$$

Also define

$$\bar{K} \equiv \frac{(a-c)^2(1+2v)^2}{4(1-v)(3-2v)^2}, \quad \hat{K} \equiv \frac{(a-c)^2}{16(1-v)^3}.$$

It is true that $\pi_1^V < \pi_1^W, \bar{K} < \hat{K}$. Our major finding for $\Gamma(a,c,v)$ is shown by the theorem below, also illustrated by Figure 9.
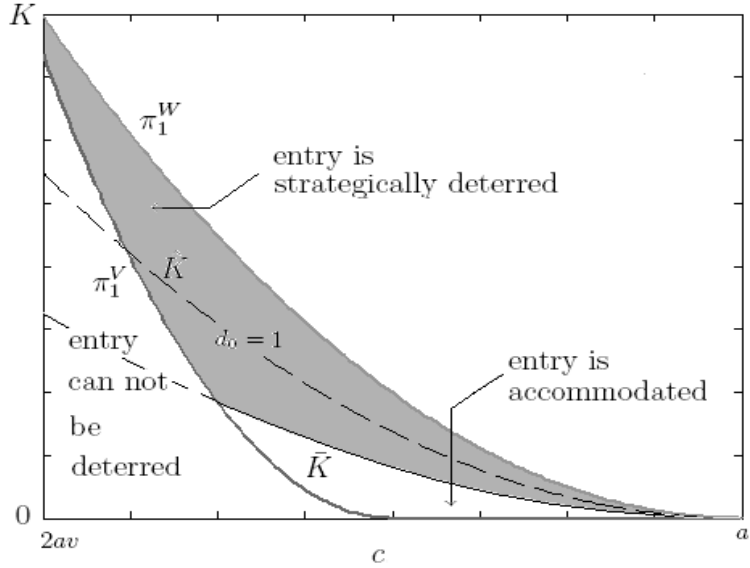

Figure 9: Major result of $\Gamma(a,c,v)$ with $a = 10, v = 0.1$.

Theorem 2 *(Figure 9) SPNE for $\Gamma(a,c,v)$ with $K \in [\pi_1^V, \pi_1^W)$ is given below.*
(I) If $K \geq \bar{K}$, entry is strategically deterred. There are two cases:
    (Ia) If $K < \hat{K}$, the unique SPNE is depicted by $(p, x^1) = ((\pi_1^W - K + C(\tau(K))/\tau(K), \tau(K))$, $d_1 = 0, x^2 = 0, q_0 = \tau(K)$;
    (Ib) If $K \geq \hat{K}$, the unique SPNE is depicted by $(p, x^1) = ((\pi_1^W - K + C(M_0)/M_0, M_0)$, $d_1 = 0, x^2 = 0, q_0 = M_0$.
(II) If $K < \bar{K}$, entry is accommodated. The unique SPNE is $(p, x^1) = ((\pi_1^W - K + C(\tilde{x}^1)/\tilde{x}^1, \tilde{x}^1), d_1 = 1, x^2 = 0, q_0 = \tilde{x}^1, q_1 = q_1^f(\tilde{x}^1)$.

There is one obvious change in our finding compared to the baseline model. When entry is strategically deterred, firm 0 always sources exclusively to firm 1. This phenomenon of course is driven by scale economies.

7 Discussion

Entry-deterring sourcing can happen with either Cournot or Bertrand rule imposed on firm 0 and firm 1's post-entry competition. Without a specific competition rule, we may have more insight on the condition which entails the strategic sourcing.

Suppose there is a perfect competitive market of good I and production cost of good I is $C(\cdot)$. Firm 0 and firm 1 compete on variables $\{y_0, y_1\}$ after firm 1's entry. For each value of x^1 which these two firms have agreed upon, if firm 1 enters, a unique NE exists in stage three, denoted as $\{y_0^*(x^1), y_1^*(x^1)\}$. Moreover, for each value of x^1, the equilibrium total quantity of good I firm 0 orders from elsewhere, denoted as $x^2(x^1)$, is unique and well defined, together with the price firm 0 has to pay, $p_2(x^1)$.

Under a given x^1, let firm 1's post-entry profit $\pi_1(y_0^*(x^1), y_1^*(x^1))$ be denoted as $\pi_1^e(x^1)$. When $x^1 = 0$, let firm 1's profit upon entry net of entry cost as $\pi_1^W - K$ (to be consistent with previous notations). Assume

(I). There exists a range of x^1, $[a, b]$ with $a, b \in \mathbb{R}^+$, such that for $x^1 \in [a, b]$, $\pi_1^e(x^1) \in [0, \pi_1^W]$ and is strictly decreasing in x^1; for $x^1 < a$, $\pi_1^e(x^1) \geq \pi_1(a)$.

When (I) is true, for $x^1 \leq b$, there exists a unique $\tau(K) \in [a, b]$, such that firm 1 enters if and only if $x^1 < \tau(K)$.

Let the equilibrium revenue in stage three under a given x^1 as $R(x^1)$. Define

$$\Pi^M \equiv \max_{x^1}[R(x^1) - C(x^1) - p_2(x^1)x^2(x^1)]$$
$$\text{s.t. } x^1 \geq \tau(K).$$

And

$$\Pi^D \equiv \max_{x^1}[R(x^1) - C(x^1) - p_2(x^1)x^2(x^1) - K]$$
$$\text{s.t. } x^1 < \tau(K).$$

Assume

(II). $\Pi^M \geq \Pi^D$.

Define $K^a \equiv \pi_1^e(a), K^b \equiv \pi_1^e(b)$. When (I), (II) are satisfied, for $K \in [K^b, K^a]$, $x^1 \geq \tau(K)$ with entry deterred is in SPNE. The reason is, on the one hand, by setting $x^1 \geq \tau(K)$, firm 1 is pushed into a non-positive profit if it enters; on the other hand, $\Pi^M \geq \Pi^D$ guarantees each a profit with entry deterred no less than its optimal duopoly profit. To see this, suppose firm 1 is just granted $\pi_1^W - K$ by acting as firm 0's supplier then staying out, which makes firm 1 indifferent between accepting the sourcing offer or not. In this case firm 0 is better off under such a sourcing contract, since it gets $\Pi^M - (\pi_1^W - K)$, no less than its optimal profit by accommodating entry, $\Pi^D - (\pi_1^W - K)$.

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