Offshore Outsourcing Induced by Domestic Providers

Yutian Chen* Pradeep Dubey† Debapriya Sen‡

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Abstract

We show that offshore outsourcing can occur even when there are no economies of scale or cost advantages for the foreign firms. What drives the phenomenon is that domestic firms, by accepting orders for intermediate goods, incur the disadvantage of becoming Stackelberg followers in the ensuing competition to sell the final good. Thus they have incentive to quote high provider prices to ward off future competitors, compelling them to outsource offshore.

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*Department of Economics, SUNY-Stony Brook, NY 11794, USA. Email: `yutchen@ic.sunysb.edu`

†Center for Game Theory, Department of Economics, SUNY-Stony Brook, NY 11794, USA & Cowles Foundation, Yale University, New Haven, CT 06520, USA. Email: `pradeepkdubey@yahoo.com`

‡Department of Economics, SUNY-Stony Brook, NY 11794, USA. Email: `dsen@notes.cc.sunysb.edu`

1 Introduction

Offshore outsourcing has witnessed rapid increase the world over and has become a topic of much discussion. Most analyses of the phenomenon focus on economies of scale and cost effectiveness (see, e.g., Shy & Stenbacka, 2003; Chen, Ishikawa & Yu, 2004; and the references therein). For instance, if there are increasing returns to scale in the production of the outsourced goods and offshore costs happen to be lower, then the pressure to cut costs will drive domestic firms to congregate on one of the foreign companies as the sole provider. On the other hand, one could also imagine a regime where decreasing returns to scale are prevalent across the whole industry. In this event, firms will partially outsource to *all* providers, including those offshore, simply in order to achieve the best average cost.[1]

We wish to bring to light a quite different, purely game-theoretic, reason for offshore outsourcing. It has to do with the possibility that foreign companies are not in a position to enter the domestic market[2] for the final product, although they are able to produce the intermediate goods required for it. Strategic considerations can now come into play that will induce domestic firms to outsource offshore.

For concreteness consider two Cournot duopolists, labeled 1 and 2, in the domestic market for the final product F. An intermediate good I is needed to manufacture F (and, to keep matters simple, x units of I can costlessly be converted into x units of F by either firm). The domestic firm 1 and a foreign company 0 can both produce I. But while 1 can convert I to F, 0 is unable to do so. Moreover 0 and 1 have constant marginal costs c_0 and c_1 for producing I and $c_1 < c_0$, thus eliminating both economies of scale and the cost advantage of the foreign firm 0.

Nonetheless it can happen that 2 will outsource I to 0.

The intuition goes roughly as follows. Suppose 0 and 1 have simultaneously quoted prices p_0 and p_1 for the supply of good I. If 2 goes to 0 to order q units of I, then 1 only knows that 2 has gone there but—thanks to the sanctity of the secrecy clause—not the amount q that 2 has ordered. So 1 and 2 remain Cournot duopolists in the ensuing subgame. In contrast, if 2 goes to 1 to order q, then 1 willy-nilly knows q. This has the

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[1] This is the basic idea in Spiegel (1993), even though *offshore* outsourcing was not the issue there.

[2] This could happen because they lack the technology, or on account of high tariffs or low quotas or simply protectionist policies put into effect by the domestic government.

effect of establishing 2 as leader in a Stackelberg game in which 1 is forced to become follower.

If costs do not vary much across the two games, 1 will earn less as a Stackelberg follower than as a Cournot duopolist. This will tempt 1 to ward off 2 by quoting p_1 sufficiently above p_0 so that, inspite of the premium that 2 is willing to pay for the privilege of being leader, 2 prefers to go to 0. The temptation can only be resisted if it is feasible for 1 to sell I at a high enough p_1, enabling it to recoup as provider what it gives up as follower. But if c_0 is not significantly above c_1, such a high p_1 can be undercut by 0 by the quote of a suitably lower p_0 that attracts 2. The upshot is that at any subgame perfect Nash equilibrium (SPNE) of our game, 2 will outsource[3] offshore to 0.

The exact argument is more intricate and the precise result is as follows. Fix the cost c_1 of the domestic provider and a linear market demand for the final good F. In Theorem 1, we establish a threshold $c^* > c_1$ such that: (I) if $c_1 < c_0 < c^*$, there is a continuum of SPNE, but 2 outsources to the foreign firm 0 at each of them; (II) if $c_0 > c^*$, there is a unique SPNE in which 2 outsources to the domestic firm 1 (at $c_0 = c^*$, both kinds of SPNE coexist). Interestingly, only one of the continuum of SPNE of case (I) survives if we introduce a "tremble" on the announcement of prices p_0 and p_1, so that they are never simultaneous (Theorem 2).

Worthy of note is the fact that it is *not* 2 who has the primary strategic incentive to outsource to 0. This resides with 1 who is anxious to ward off 2 and force 2 to turn to 0. The anxiety gets played out when 0 does not have a severe cost disadvantage compared to 1. Otherwise, 1 is happy to strike a deal with 2 since it can get high provider prices that compensate it for becoming a follower. Which subgame gets played—Cournot or Stackelberg—is thus not a priori fixed, but endogenous to equilibrium.

When economies of scale are brought into the picture, a new strategic consideration arises (see Chen & Dubey, 2005). Now 2 must worry that if it outsources to 1, then 1 will develop a cost advantage on account of economies of scale. In other words, 1 will be able to produce I for itself at an average cost that is lower than the p_1 it is charging to 2. This might outweigh any leadership advantage that 2 obtains by going to 1. So, foreseeing a competitor in 1 that is fierce inspite of being a follower, 2 would prefer to outsource to 0 as long as p_0 is not too much above p_1. This, in turn, will happen if 0's

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[3] Since $c_1 < c_0$, 1 will of course produce I inside for its own use.

costs are not significantly higher than 1's. But then, if 2 is outsourcing to 0, economies of scale will drive 1 to outsource to 0 as well. The phenomenon—that both domestic firms outsource offshore—survives even when perfect information is put into the game, i.e., we postulate that 1 must always learn of 2's actions and be resigned to being the Stackelberg follower irrespective of the outsourcing pattern. Economies of scale play the decisive role here. (With constant returns to scale, offshore outsourcing breaks down in the presence of perfect information.) Finally it can be shown that as the number of firms outsourcing I increases, the maximum cost disadvantage that foreign firms can be permitted to have (and still sustain offshore outsourcing) also increases. This, too, is critically dependent on increasing returns to scale.

2 The Model

As was said, firms 1 and 2 are duopolists within a country in the the market for a final good F. An intermediate good I is required to manufacture F and, within the country, only firm 1 has the capability to produce I. There is a foreign firm 0, which also has this capability, and is vying to get orders to manufacture I for 1 and 2. What distinguishes 0 from 1 is that 0 cannot enter the market for F. Firm 0's sole means of profit is the manufacture of good I outsourced to it by the domestic firms. The strategic interaction between the firms can be viewed as a game Γ in extensive form (see Figure 1).

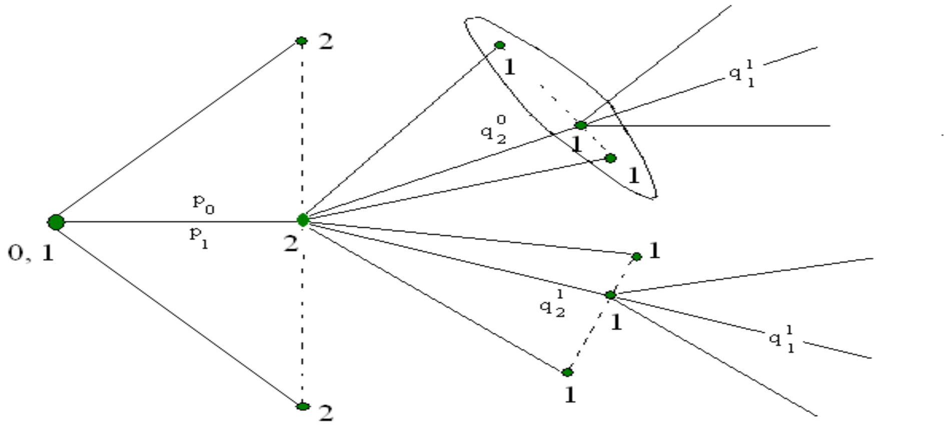

Figure 1: The Game Γ

We assume that firm 1 can produce good I at a *cheaper* cost than the foreign firm 0. Thus it is evident that 1 will always produce good I internally, and we suppress the irrelevant option for it to outsource good I to 0.

In the first stage of the game Γ, firms 0 and 1 simultaneously[4] announce prices p_0 and p_1 at which they are ready to provide good I. Then 2 decides[5] how much of I to order and from whom. Firm 1 will know the quantity ordered by 2 if and only if 2 orders from 1. In the last stage, firms 1 and 2 compete via quantities in the market for good F. Thus if 2 outsources good I to 0, what ensues is a standard Cournot duopoly between 1 and 2. If 2 goes to 1 for good I, a Stackelberg duopoly is created with 2 as the leader.

For simplicity, first consider a linear model. The inverse market demand for good F is given by $P = a - Q$, where Q denotes the total quantity of F produced by firms 1 and 2, and P denotes the price of F. The constant marginal cost of production of good I is given by c_0 and c_1 for 0 and 1. Furthermore both 1 and 2 can convert x units of good I into x units of good F at the same constant marginal cost, which w.l.o.g we normalize to zero. Assume

$$0 < c_1 < c_0 < \frac{c_1 + a}{2}. \tag{1}$$

The condition $c_1 < c_0$ gives a cost disadvantage to the foreign firm and loads the dice against good I being outsourced[6] to it. The last inequality prevents 1 from automatically becoming a monopolist in the market for good F.

It remains to describe the payoffs of the three firms at the terminal nodes of the game tree. Denote

$$q_j^i \equiv \text{ quantity of good } I \text{ ordered by firm } j \text{ from firm } i$$

where $i \in \{0, 1\}$ and $j \in \{1, 2\}$. Any path in the game tree is then specified by $p = (p_0, p_1)$ and $q = \{q_j^i\}_{j=1,2}^{i=0,1}$, with the understanding[7] that $q_1^0 = 0$ and $q_2^0 q_2^1 = 0$. The payoff to firm i is $\Pi_i(p, q)$, where

$$\Pi_0(p, q) = p_0 q_2^0 - c_0 q_2^0$$

$$\Pi_1(p, q) = (a - q_1^0 - q_2^0 - q_2^1) q_1^0 + p_1 q_2^1 - c_1(q_1^1 + q_2^1)$$

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[4] We examine sequential price announcements in Section 4.5.

[5] For simplicity we suppose that 2 does not go to both providers.

[6] If $c_0 < c_1$, then it is trivial that both 1 and 2 will outsource good I to 0.

[7] As was said, 1 will never outsource I to 0, hence $q_1^0 = 0$. For simplicity, we assume that 2 will order good I from either 0 or 1, never both, hence $q_2^0 q_2^1 = 0$.

$$\Pi_2(p,q) = (a - q_1^0 - q_2^0 - q_2^1)(q_2^0 + q_2^1) - p_0 q_2^0 - p_1 q_2^1$$

The game is completely specified by the three parameters c_1, c_0, a and hence we denote it $\Gamma(c_1, c_0, a)$.

3 The Main Result

Put

$$c^* = \frac{13}{14}c_1 + \frac{1}{14}a$$

and observe that (1) implies

$$c_1 < c^* < \frac{c_1 + a}{2}.$$

Also define the function

$$\tau(p_0) = \frac{3 - 2\sqrt{2}}{6}(a + c_1) + \frac{2\sqrt{2}}{3}p_0.$$

By an SPNE of $\Gamma(c_1, c_0, a)$, we shall mean a *subgame perfect Nash equilibrium in pure strategies* of the game $\Gamma(c_1, c_0, a)$, with the proviso that no player uses a weakly dominated strategy.[8] Our main result asserts that, if the the cost disadvantage of the foreign firm 0 is not too significant (i.e. $c_0 - c_1$ is not too large), then 2 will outsource good I to 0 in SPNE:

Theorem 1. *There exist SPNE of* $\Gamma(c_1, c_0, a)$.

(I) *If* $c_0 \in [c_1, c^*)$, *the SPNE of* $\Gamma(c_1, c_0, a)$ *are indexed by provider prices* (p_0, p_1) *in the set* $\{(p_0, \tau(p_0)) : p_0 \in [c_0, c^*]\}$; *and, moreover, every SPNE has firm* 2 *outsourcing the intermediate good to the foreign firm* 0.

(II) *If* $c_0 \in \left(c^*, \frac{c_1 + a}{2}\right)$, *then there is a unique SPNE of* $\Gamma(c_1, c_0, a)$ *with* $(p_0, p_1) = (c_0, \tau(c_0))$ *and with firm* 2 *choosing the domestic firm* 1 *for the provision of the intermediate good.*

(III) *Finally, if* $c_0 = c^*$, *there are two SPNE of* $\Gamma(c_1, c_0, a)$ *with the same provider prices* $(p_0, p_1) = (c^*, \tau(c^*))$, *but firm* 2 *chooses* 1 *as the provider in one SPNE and outsources to* 0 *in the other.*

Proof. See Section 4. ■

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[8] In our game, SPNE coincides with trembling-hand perfect NE of $\Gamma(c_1, c_0, a)$.

3.1 Sequential Price Announcement

Let $\Gamma_{0,1}(c_1, c_0, a)$ be the game obtained from $\Gamma(c_1, c_0, a)$ with one modification: firm 0 announces its price p_0 first; and then, knowing p_0, firm 1 announces p_1. Similarly $\Gamma_{1,0}(c_1, c_0, a)$ is the game in which 1 announces p_1 first and 0 announces p_0 afterwards.

Theorem 2. *If* $c_0 \in [c_1, c^*)$, *there is a unique SPNE in* $\Gamma_{0,1}(c_1, c_0, a)$ *and in* $\Gamma_{1,0}(c_1, c_0, a)$, *and they coincide with the SPNE of* $\Gamma(c_1, c_0, a)$ *indexed by the provider prices* $(c^*, \tau(c^*))$.

Proof. See Section 4. ■

Theorem 2 selects one of the multiple equilibria in case (I) of Theorem 1 and is tantamount to an equilibrium refinement. Imagine continuous, independent "trembles" on the time at which 0 and 1 announce p_0 and p_1. Then the probability that p_0 and p_1 are simultaneous is zero; one of the games $\Gamma_{0,1}(c_1, c_0, a)$ or $\Gamma_{1,0}(c_1, c_0, a)$ will almost always come into effect, selecting the $(c^*, \tau(c^*))$-SPNE of $\Gamma(c_1, c_0, a)$.

4 Proofs

4.1 Basic Facts on Cournot and Stackelberg Games

Fix throughout the inverse demand $P = a - Q$ and the (constant, marginal) cost of firm 1 at c_1, where $0 \leq c_1 < a$. Depending on the (constant, marginal) cost $c_2 \geq 0$ of firm 2, we shall get different games. Denote by $\mathcal{S}^{21}(c_2)$ the Stackelberg duopoly game with 2 as the leader and 1 the follower; and by $\mathcal{C}(c_2)$ the Cournot duopoly game between 1 and 2. The games $\mathcal{S}^{21}(c_2)$ and $\mathcal{C}(c_2)$ have unique SPNE for[9] any $c_2 \geq 0$.

Let $f(c_2)$ and $\ell(c_2)$ denote the profits of 1 (follower) and 2 (leader) in the SPNE of $\mathcal{S}^{21}(c_2)$. Let $\kappa_1(c_2)$ and $\kappa_2(c_2)$ denote the corresponding profits in $\mathcal{C}(c_2)$. Finally, let $q(c_2)$ and $x(c_2)$ denote the output produced by 2 in the SPNE of $\mathcal{C}(c_2)$ and $\mathcal{S}^{21}(c_2)$ respectively. The following facts can easily be verified.

(i) $q(c_2)$, $x(c_2)$, $\ell(c_2)$ *and* $\kappa_2(c_2)$ *are positive for* $0 \leq c_2 < (c_1 + a)/2$; *and, for* $c_2 \geq (c_1 + a)/2$, *all of them are zero.*

(ii) $\ell(c_2)$ *and* $\kappa_2(c_2)$ *are strictly decreasing and* $\ell(c_2) > \kappa_2(c_2)$, *for* $c_2 \in [0, (c_1 + a)/2)$.

(iii) $f(c_2)$ *and* $\kappa_1(c_2)$ *are increasing and* $f(c_2) \leq \kappa_1(c_2)$, *for* $c_2 \geq 0$.

(iv) $f(c_2)$ *and* $\kappa_1(c_2)$ *are both positive for* $c_2 \in [c_1, (c_1 + a)/2]$.

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[9] In the Cournot game $\mathcal{C}(c_2)$, SPNE is just NE.

4.2 Basic Facts about the Game Γ

(v) *In any SPNE of* Γ, $p_0 \geq c_0 > c_1$ *and* 1 *never outsources to 0.*

To see this, observe that when $p_0 < c_0$, firm 0 gets a negative payoff if any positive amount is ordered from it and zero otherwise. But by setting $p_0 = c_0$, it can ensure a constant zero payoff. So it is a weakly dominated strategy for firm 0 to set $p_0 < c_0$. Since $c_0 > c_1$ by hypothesis (see (1)), 1 is better off producing inside than outsourcing to 0, proving (v).

It will be useful to define the binary decision variable $d \in \{0, 1\}$ indicating who 2 chooses as its provider. Then given any announcement p_0, p_1, the decision d implies an effective cost $c_2(d) = p_d$ for firm 2. If $d = 0$, the Cournot game $\mathcal{C}(p_0)$ ensues; and if $d = 1$, we get the Stackelberg game $\mathcal{S}^{21}(p_1)$.

(vi) *In any SPNE of* Γ, $p_1 \geq c_1$.

If $p_1 < c_1 < (c_1 + a)/2$ (the second inequality coming from (1)), then (see (ii)) 2 gets $\ell(p_1) > \ell(c_1) > \kappa_2(c_1)$ by choosing $d = 1$ and $\kappa_2(p_0) \leq \kappa_2(c_0) \leq \kappa_2(c_1)$ by choosing $d = 0$. So when $p_1 < c_1$, 2 will choose $d = 1$. But then 1 gets $F(p_1) \equiv f(p_1) + (p_1 - c_1)q(p_1) < f(p_1)$, since (by (i)) $q(p_1) > 0$. But by setting $p_1 = (c_1 + a)/2$, 1 can ensure that (see (i) again) if 2 chooses $d = 1$, it will order 0 in which case 1 will get the monopoly profit exceeding $F(p_1)$. And if $d = 0$, 1 will get the (possibly lower) Cournot profit $\kappa_1(p_0) \geq \kappa_1(c_0) \geq f(p_1) > F(p_1)$ (the inequalities here follow from (iv) and (v)). In either case, 1 gains by the unilateral deviation, a contradiction establishing (vi).

(vii) *If we restrict* $p_0, p_1 \leq (c_1 + a)/2$, *the SPNE of* Γ *are unaffected.*

This follows at once from (i).

4.3 Some Lemmas

By (vii), we may restrict price announcements to satisfy $p_0 \in [c_0, (c_1 + a)/2]$ and $p_1 \in [c_1, (c_1 + a)/2]$, which we shall do from now on.

Given any (p_0, p_1), if $d = 0$, the SPNE payoffs of 0, 1 and 2 are given by $\kappa_0(p_0) = (p_0 - c_0)x(p_0)$, $\kappa_1(p_0)$ and $\kappa_2(p_0)$. And if $d = 1$, these are zero, $\ell(p_1)$ and $F(p_1) \equiv f(p_1) + (p_1 - c_1)q(p_1)$.

The functions $\lambda \equiv F^{-1} \circ \kappa_1$ and $\tau \equiv \ell^{-1} \circ \kappa_2$ will play a decisive role in our analysis. They compare the Stackelberg and Cournot games from the standpoint of 1 and

2 respectively. We show that they are well-defined and describe their properties in the lemmas below.

For any announcement (p_0, p_1), it is evident that firm 2 chooses $d = 0$ if $\kappa_2(p_0) > \ell(p_1)$ and $d = 1$ if $\kappa_2(p_0) < \ell(p_1)$. The firm is indifferent between $d = 0$ and $d = 1$ if $\kappa_2(p_0) = \ell(p_1)$ and $\tau(p_0)$ gives this point of indifference. In other words, for any p_0 incurred as its cost in the Cournot game $\mathcal{C}(p_0)$, $\tau(p_0)$ is the maximum cost p_1 that 2 is willing to bear in order to switch to being leader in the Stackelberg game $\mathcal{S}^{21}(p_1)$. The situation is depicted in Figure 2 and spelled out below.

Define

$$\Omega \equiv [c_1, (c_1 + a)/2]$$

and

$$\tau(p_0) \equiv (3 - 2\sqrt{2})(c_1 + a)/6 + 2\sqrt{2}p_0/3.$$

Lemma 1. (Figure 2) *The function* τ *is a strictly increasing function from* Ω *to* Ω. *Moreover, for all* $p_0 \in \Omega$,

(a) $\ell(\tau(p_0)) = \kappa_2(p_0)$.

(b) $\tau(p_0) > p_0$, *except for* $p_0 = (c_1 + a)/2$ *when* $\tau(p_0) = p_0$.

(c) $\ell(p_1) > \kappa_2(p_0)$ *if* $p_1 \in [c_1, \tau(p_0))$ *and* $\ell(p_1) < \kappa_2(p_0)$ *if* $p_1 \in (\tau(p_0), (c_1 + a)/2]$.

Proof. Straightforward computation. ■

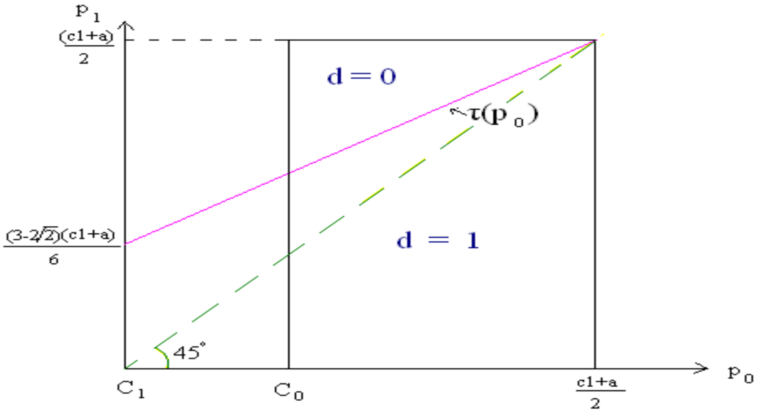

Figure 2: The Function $\tau(p_0)$

Next define

$$\tilde{c} = 55c_1/62 + 7a/62 \tag{2}$$

observe that $c_1 < \tilde{c} < (c_1 + a)/2$ by (1).

Lemma 2. (Figure 3) *Both κ_1 and F are strictly increasing on Ω. Moreover, $F < \kappa_1$ on $[c_1, \tilde{c})$, $F > \kappa_1$ on $(\tilde{c}, (c_1 + a)/2)$, $F(\tilde{c}) = \kappa_1(\tilde{c})$ and $F((c_1 + a)/2) = \kappa_1((c_1 + a)/2)$.*

Proof. Straightforward computation. ■

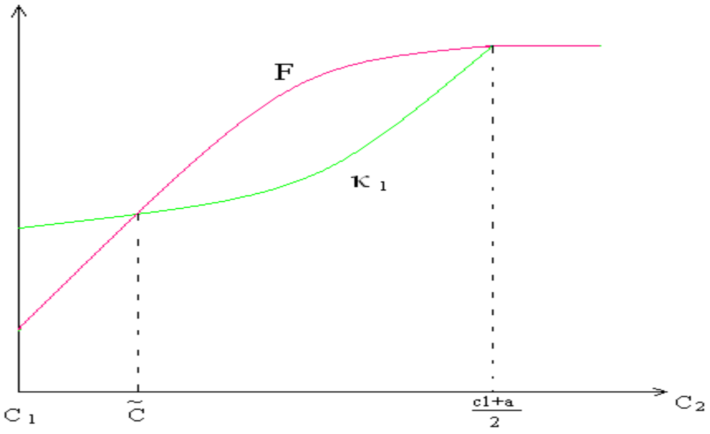

Figure 3: The Functions κ_1 and F

Lemma 3. *In any SPNE of $\Gamma(c_1, c_0, a)$, if $d = 1$, then $p_0 = c_0$ and $p_1 = \tau(c_0)$.*

Proof. First we claim that if $d = 1$ then $p_1 = \tau(p_0)$. By Lemma 1, we must have $p_1 \leq \tau(p_0)$, otherwise 2 would have chosen $d = 0$. If $p_1 < \tau(p_0)$, let 1 raise its price to $p_1 + \varepsilon < \tau(p_0)$. By Lemma 1, firm 2 will continue to choose $d = 1$. Thus the payoff of 1 will continue to be given by F after the deviation. But $F(p_1 + \varepsilon) > F(p_1)$ by Lemma 2, showing that firm 1 has improved, a contradiction.

It remains to show that $p_0 = c_0$. If not, $p_0 > c_0$ by (i). Let 0 deviate to a price p_0' where $c_0 < p_0' < p_0$. Then by Lemma 1, firm 2 will choose $d = 0$ and then 0 will earn a positive payoff. This is a contradiction since firm 0 was earning zero before the deviation when $d = 1$. ■

Now consider firm 1. We shall compare the payoffs $F(c_2)$ (the payoff of firm 1 when 1 is the follower in $\mathcal{S}^{21}(c_2)$ and charges $p_1 = c_2$ to firm 2) and $\kappa_1(c_2)$ (the payoff of firm 1 in the $\mathcal{C}(c_2)$ where the cost of 2 is c_2). For any c_2, we shall define $\lambda(c_2)$ to be the minimum cost of firm 2 at which 1 is willing to switch from the Cournot game $\mathcal{C}(c_2)$ to being follower in the Stackelberg game $\mathcal{S}^{21}(\lambda(c_2))$. Precisely

$$\lambda : [0, \tilde{c}] \to [0, \tilde{c}]$$

is given by

$$\lambda \equiv F^{-1} \circ \kappa_1.$$

Lemma 2 shows that λ is well-defined, strictly increasing and $\lambda(\tilde{c}) = \tilde{c}$.

Lemma 4. (Figure 4) *Let* $c_2 \in [c_1, \tilde{c}]$. *Then* $\kappa_1(c_2) = F(\lambda(c_2))$, $F(x) < \kappa_1(c_2)$ *for* $x < \lambda(c_2)$ *and* $F(x) > \kappa_1(c_2)$ *for* $x > \lambda(c_2)$.

Proof. Follows from Lemma 2 and the definition of λ. ■

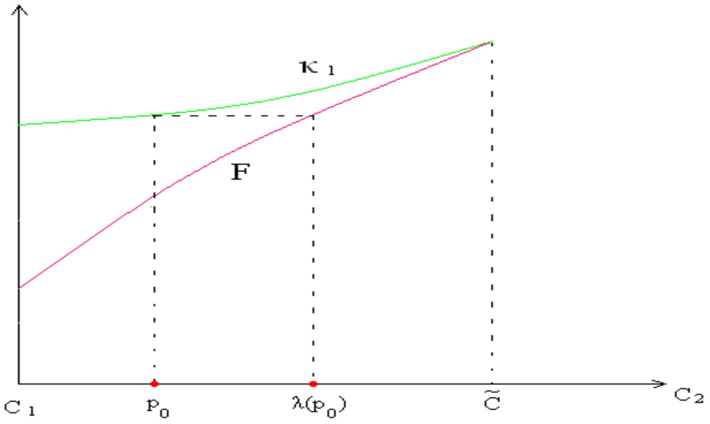

Figure 4: The Function λ

The next lemma compares the functions τ and λ. Define

$$c^* = 13c_1/14 + a/14 \tag{3}$$

and observe from (1) and (2) that

$$c_1 < c^* < \tilde{c}. \tag{4}$$

Lemma 5. (Figure 5) *Let* $c_2 \in [c_1, \tilde{c}]$. *Then* $\lambda(c^*) = \tau(c^*)$, $\tau(c_2) < \lambda(c_2)$ *for* $c_2 \in [c_1, c^*)$, $\tau(c_2) > \lambda(c_2)$ *for* $c_2 \in (c^*, \tilde{c}]$.

Proof. Follows from Lemma 2 and the definition of λ. ■

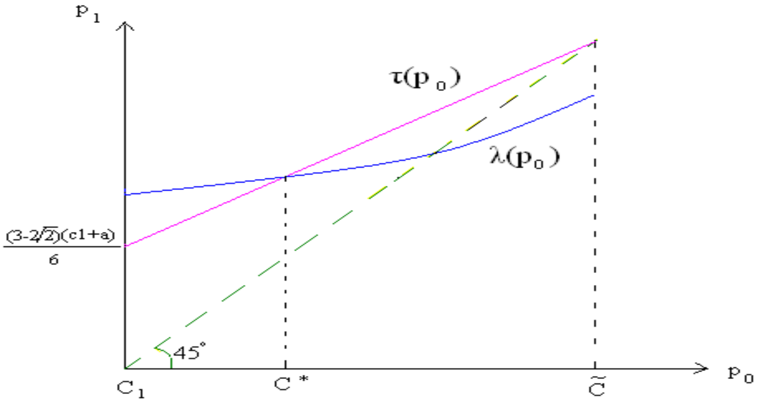

Figure 5: $\tau(p_0)$ and $\lambda(p_0)$

Lemma 6. *In any SPNE of* $\Gamma(c_1, c_0, a)$, *if* $d = 0$, *then* $p_0 \leq c^*$.

Proof. First we show that $p_0 < (c_1 + a)/2$. For if $p_0 = (c_1 + a)/2 > c_0$, then (by (i)), firm 0 gets zero payoff. Let 0 reduce its price marginally, keeping it above c_0. By (i) and Lemma 1 (Figure 1), firm 2 will still choose $d = 0$ and order a positive amount, with the upshot that 0 will earn a positive payoff, a contradiction.

Next we show that $p_0 < \tilde{c}$. Suppose $\tilde{c} \leq p_0 < (c_1 + a)/2$. Then by Lemma 2 (Figure 3), $F(p_0) \geq \kappa_1(p_0) \equiv$ the SPNE payoff of 1. Since $d = 0$, we have $p_1 \geq \tau(p_0)$ by Lemma 1 (Figure 1). Let firm 1 change p_1 to $p_1' \equiv \tau(p_0) - \varepsilon$, inducing (again by Lemma 1) firm 2 to choose $d = 1$ and getting payoff $F(p_1')$. But Lemma 1 also implies that $\tau(p_0) > p_0$, so we have $p_1' > p_0 \geq \tilde{c}$ for small enough ε. We deduce $F(p_1') > F(p_0) \geq \kappa_1(p_0)$ from Lemma 2 (Figure 3), showing that 1 is better off by deviating to p_1', a contradiction.

Recall from (4) that $c_1 < c^* < \tilde{c}$. Suppose $c^* < p_0 < \tilde{c}$, in which case $\lambda(p_0) < \tau(p_0)$ by Lemma 5. Since $d = 0$, we have $p_1 \geq \tau(p_0)$ by Lemma 1 (Figure 1). Let firm 1 change p_1 to $p_1' \equiv \lambda(p_0) + \varepsilon < \tau(p_0)$, for small enough ε, thus inducing (again by Lemma 1) firm 2 to choose $d = 1$ and getting payoff $F(p_1')$. By Lemma 2, $F(p_1') > F(\lambda(p_0)) = \kappa_1(p_0)$, showing that 1 is better off by deviating to p_1', a contradiction. Lemma 6 is proved. ■

Lemma 7. s_0 *is increasing in* p_0 *for* $p_0 \in [c_1, \tilde{c}]$.

Proof. A simple calculation shows that $s_0(p_0) = (p_0 - c_0)x(p_0) = (p_0 - c_0)(c_1 + a - 2p_0)/3$ for $p_0 \in \Omega$. Observing that $s_0(p_0)$ is increasing uptil $p_0 = p^*$ where $p^* \equiv (c_1 + a + 2c_0)/4$, and that $p^* - \tilde{c} = [17(a - c_1) + 62(c_0 - c_1)]/124 > 0$, the lemma follows. ■

4.4 Proof of Theorem 1

Proof of (I). Consider $c_0 < c^* < (c_1 + a)/2$. We submit that $d = 0$ at any SPNE. For if $d = 1$, we must have $p_0 = c_0$ and $p_1 = \tau(c_0)$ by Lemma 3. Then 1 gets payoff $F(p_1) = F(\tau(c_0))$. Let 1 deviate and choose a higher price. By Lemma 1, this will induce firm 2 to choose $d = 0$ and so 1 will get payoff $\kappa_1(p_0) = \kappa_1(c_0)$. Since $c_0 < c^*$, $F(\tau(c_0)) < F(\lambda(c_0)) = \kappa_1(c_0)$ by Lemmas 4 and 5, showing that 1 has improved, a contradiction.

Now we turn to the task of characterizing SPNE with $d = 0$. We must have $p_0 \leq c^*$ (Lemma 6) and $p_1 \geq \tau(p_0)$ (Lemma 1). If $p_1 > \tau(p_0)$, then firm 2 strictly prefers $d = 0$ to $d = 1$. Then by (4) and Lemma 7, 0 can improve its payoff by slightly increasing its price. So we must have $p_1 = \tau(p_0)$. This proves that SPNE must be of the type we have claimed.

It remains to show that for any (p_0, p_1) satisfying $p_0 \in [c_0, c^*]$ and $p_1 = \tau(p_0)$, we do get an SPNE with $d = 0$. First observe that 2 is indifferent between $d = 0$ and $d = 1$ and cannot gain by any unilateral deviation. Next by Lemma 7, firm 0 can only gain by increasing p_0, but then (by Lemma 1), firm 2 will choose $d = 1$ and firm 0 will get zero. Finally, consider firm 1, who is getting $\kappa_1(p_0)$. If 1 raises its price, 2 will still choose $d = 0$ and 1 will not gain. If 1 lowers its price to $p_1' < \tau(p_0) = p_1$, then 2 will choose $d = 1$ and 1 will get $F(p_1') < F(\tau(p_0))$ by the monotonicity of F (Lemma 2). But since $p_0 \leq c^*$, we have $\tau(p_0) \leq \lambda(p_0)$ by Lemma 5, so that $F(\tau(p_0)) \leq F(\lambda(p_0)) = \kappa_1(p_0)$. We conclude that $F(p_1') < \kappa_1(p_0)$, showing that 1 cannot improve either. This completes the proof of part (i).

Proof of (II). We know that $p_0 \geq c_0$ (by (v)). By Lemma 6, we must have $p_0 \leq c^*$ if $d = 0$. So when $c_0 > c^*$, we must have $d = 1$ in any SPNE; and then, by Lemma 3, $p_0 = c_0$ and $p_1 = \tau(c_0)$.

It remains to show that this is indeed an SPNE with $d = 1$. As before, 2 cannot gain by unilateral deviation. As for 0, it cannot lower its price, being already at its lower bound c_0 and there is no point in raising it either because 2 will continue to choose $d = 1$. Finally, consider firm 1, who is getting payoff $F(\tau(c_0))$. By the monotonicity of F, 1 cannot gain by lowering its price. If 1 raises its price, 2 will choose $d = 0$ and 1 will get $\kappa_1(c_0)$. Consider two cases. If $c_0 \geq \tilde{c}$, we have $F(\tau(c_0)) > F(c_0) \geq \kappa_1(c_0)$ by Lemma 4, so 1 does not gain. If $c^* < c_0 < \tilde{c}$, we have $\tau(c_0) > \lambda(c_0)$ by Lemma 5, so

$F(\tau(c_0)) > F(\lambda(c_0)) = \kappa_1(c_0)$ and once again 1 does not gain.

Proof of (III). The argument is as in parts (I) and (II), hence omitted. ■

4.5 Proof of Theorem 2

This follows at once from Theorem 1 and the fact that the payoffs of both firms 0 and 1 increase with the index $(p_0, \tau(p_0))$ of the SPNE in the interval $p_0 \in [c_0, c^*]$. ■

5 Multiple Providers and outsourcers

Our analysis extends to the case when there are several providers, domestic as well as foreign, and several firms seeking to procure the intermediate good from them. To get unique SPNE, it now becomes necessary to introduce a refinement which requires players to make best responses (play Nash) even at nodes that are not reached with positive probability (i.e., to consider weak perfect Bayesian Nash equilibria). The cost disadvantage permissible to foreign firms—so that offshore outsourcing still occurs—diminishes as the number of providers and seekers increases, but it does not disappear. (The analysis is along the same general lines as in this paper, but the details are more complicated and we felt it best that the reader be spared them.) We reiterate that, in contrast, competition makes room for *more* cost disadvantage to foreign firms when there are increasing returns to scale.

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