Strategic Outsourcing under Economies of Scale

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Abstract

Economies of scale in upstream production can lead both disintegrated downstream firm as well as its vertically integrated rival to outsource offshore for intermediate goods, even if offshore production has moderate cost disadvantage compared to in-house production of the vertically integrated firm.

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JEL Classification: D41, L11, L13

1 Introduction

In this era of globalization, outsourcing has become a prominent industry practice. It has been observed that scale economies could play an important role in determining firms' sourcing patterns.[1] The aim of this paper is to explore the strategic effect of scale economies in driving the outsourcing trend.

We carry out our analysis under a Cournot duopoly model in the downstream final good market. One of these downstream firms is vertically integrated, which can produce the required intermediate good in-house, whereas the other firm is disintegrated and cannot produce it. A competitive fringe of firms located offshore can also produce the intermediate good. The production technology of the intermediate good of both the integrated firm and the fringe exhibits economies of scale. The disintegrated firm can acquire the intermediate good either from its integrated rival or from the offshore fringe, while the integrated firm can either produce it in-house or acquire it from the fringe.

Our main result is that, in this scenario, both downstream firms—the disintegrated firm as well as its integrated rival— will outsource to the offshore fringe *even if the fringe has*

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[1]It is noticed that "the importance of economies of scale is the most talked about aspect of outsourcing" (Outsourcing Journal, May 2001. Source: http://www.outsourcing-journal.com/may2001-insights.html). A major reason for firms to outsource is to exploit "an outside provider's lower cost structure, which may be the result of a greater economies of scale" (Burkholder (2005), p. 52). For example, in IT outsourcing, it is reported that "in many cases the customer wants to outsource the IT-specific know-how" because "vendor specialized in IT offers attractive advantages including economies of scale" (Rost (2006), p. 19).

a cost disadvantage in the intermediate good compared to the integrated firm, so long as the disadvantage is not too severe.[2]

This result is driven by the strategic effect of economies of scale. In the presence of scale economies, an outsourcing order from the disintegrated firm to its integrated rival makes the rival more efficient by lowering its marginal cost of production. Unwilling to give such an efficiency edge to its downstream rival, the disintegrated firm turns to the offshore fringe for its intermediate good. Given that, scale economies of the fringe can be better exploited if the integrated firm outsources to the fringe as well. This leads both downstream firms to outsource offshore, with the integrated firm giving up its in-house production of the intermediate good. This strategic effect of scale economies dominates any cost disadvantage the offshore fringe might have, as long as such disadvantage is not substantial.

There is a large literature that considers various strategic aspects of sourcing (see, e.g., Cachon and Harker (2002), Shy and Stenbacka (2003), Chen et al. (2004), Heavner (2004), Chen (2005), Buehler and Haucap (2006), Arya et al. (2008a,b), Chen et al. (2009)). The paper most closely related to ours is Chen (2005), who argues that an integrated firm might have incentive to disintegrate in order to better exploit scale economies. In both papers, scale economies creates reluctance on the part of disintegrated downstream firm to purchase from its integrated rival. However, our paper differs from Chen (2005) in several respects. First, in Chen (2005) the integrated firm is the only one in the upstream market whose technology exhibits scale economies, while all other firms in that market are part of a competitive fringe and produce at constant marginal cost. In contrast, in our paper the technology of the integrated firm as well as the fringe has economies of scale. Scale economies of the fringe in our model drive *both* downstream firms—disintegrated as well as integrated—to order from the fringe. This is an additional strategic effect of economies of scale which is absent in the model of Chen (2005). Second, these two papers intend to explain different economic phenomena. Chen (2005) focuses on vertical disintegration as a device for integrated firm to win upstream competition, whereas in our paper, the objective is to highlight the strategic role of scale economies in driving the offshore outsourcing trend. In particular, we show that as long as offshore providers specialize on upstream production, the integrated firm will give up its in-house production and join its disintegrated rival in outsourcing offshore.[3]

Cachon and Harker (2002) illustrate a different strategic effect scale economies might have to favor outsourcing. When final good competitors face scale economies in their intermediate good production, in-house production of the intermediate good leads them strong incentive

[2]According to our result, the presence of economies of scale may lead the trend of offshore outsourcing to well persist even when offshore cost advantage diminishes. In fact, nowadays evidences are showing that difference in labor costs between countries becomes smaller as time goes by. To quote one observation, "in most offshore countries, the salaries for software developers have been continually growing over the past few years. Further future growth is to be expected" (Rost (2006), p. 35).

[3]There are evidences which support the argument that, firms by *not* entering the final-good market, are more likely to attract orders for intermediate goods. For example, in 1980's, US companies in the electronics industry were seeking "to diversify their sources of supply". In order to get the US business, Malaysia and Singapore emphasized in their government policies that both nations "were not attempting to promote national champions in the electronic industry", but rather "to build a complementary supply base, not to create local rivals that might displace foreign producers". Their success in becoming major supply hubs for electronic components is well documented (see Ravenhill (2003)). Although both nations have the advantage of low labor cost, their deliberate abstention from final-good markets also created them a competitive edge in markets of intermediate goods.

for cutting prices in the final good market in order to boost selling thus better exploit scale economies. Instead, if they outsource the intermediate good to upstream provider by paying unit price, such incentive for further cutting downstream prices is weakened, which mitigates downstream competition therefore may lead to both firms' advantage.

The paper is organized as follows. Section 2 presents our model and gives our major result. Section 3 fully characterizes equilibrium of the model, also gives the proof. Section 4 then discusses and concludes.

2 Model and Major Result

Firms I and D are Cournot duopolists in the market for a final good β. Let q_k be the quantity of β produced by firm k, $k = I, D$ and $Q = q_I + q_D$. The inverse demand of good β is $P = \max\{a - Q, 0\}$, where $a > 0$.

An intermediate good α is required to produce β. Firm I can manufacture α, but D cannot. In other words, firm I is a vertically *integrated* firm while D is *disintegrated*. There is also an "outside" competitive fringe of identical firms which can manufacture α. Let U be a representative firm of this fringe.

I and D can convert one unit of α into one unit of β at the same constant average cost, which is normalized to be zero. Both I and U face economies of scale in producing α. Specifically, for $j = I, U$, the cost function $C_j(q)$ of firm j is given by

$$C_I(q) = \begin{cases} bq - cq^2 & \text{for} \quad q \le b/2c \\ b^2/4c & \text{for} \quad q > b/2c \end{cases} ; \quad C_U(q) = \begin{cases} \lambda bq - cq^2 & \text{for} \quad q \le \lambda b/2c \\ (\lambda b)^2/4c & \text{for} \quad q > \lambda b/2c \end{cases}$$

We make the following assumptions:

$$b/2c > a > \lambda b > 0. \tag{1}$$

The first inequality guarantees that, in equilibrium the production of good α entails positive marginal cost. Also assume

$$1 \le \lambda < \bar{\lambda} \equiv (a + b - 2ac)/2b(1 - c). \tag{2}$$

Here $\lambda \ge 1$ catches that U may have a cost disadvantage compared to I;[4] $\lambda < \bar{\lambda}$ guarantees that D will produce positive quantity when it orders good α exclusively from U, given that I produces α by itself.[5] Note that for $j = I, U$, average cost $AC_j(q) = C_j(q)/q$ is linearly decreasing in q for $q \le b/2c$. Moreover, (1) and (2) imply

$$1/2 > b/2a > c > 0, \tag{3}$$

so that $C_j(q), j = I, U$ is not "too concave" in order to ensure the existence and uniqueness of equilibrium in the market β.

[4]This assumption allows us to focus on the strategic effect of scale economies in firms' sourcing decision. Our model is readily extended to the case when offshore suppliers have cost advantage.

[5]If this assumption is violated, then the cost of α for U is too large and D has to rely entirely on I for its required α. Then it is optimal for I to charge a very high price of α for D. This will drive D out of the market β and establish I a monopolist. It can be shown from (2) that $b/2c > \bar{\lambda} b$, so $\bar{\lambda}$ satisfies (1).

For $k = I, D$, firm k has two alternative sources of acquiring α: either exclusively from U or exclusively from I.[6] Denote the sourcing mode of firm k by δ_k. Then $\delta_k = j$ if firm k orders α from $j = U, I$, with $\delta_I = I$ meaning that I produces α by itself. In our model U is a non-strategic player due to the perfect competition.[7] The strategic interaction between I and D is modelled into a three-stage game, denoted as game G:

Stage one. I announces price p_I for good α.

Stage two. I and D simultaneously choose their sourcing modes δ_I, δ_D.

Stage three. I and D engage in quantity competition in the market β.

Solution concept for the game is Subgame Perfect Nash Equilibrium (SPNE) in pure strategy.

Let X be the total quantity of α outsourced to U. For $X > 0$, average production cost of U is

$$v \equiv v(X) \equiv AC(X) = \lambda b - cX.$$

Since U is a non-strategic player, the price of U for good α when U receives total outsourcing order X is given by $v(X)$. There exist four outsourcing regimes, denoted by $\delta \equiv \delta_I \delta_D \in \{II, IU, UU, UI\}$. If $\delta = II$, then $X = 0$; if $\delta = IU$, then $X = q_D$; if $\delta = UU$, then $X = q_I + q_D = Q$. Finally, if $\delta = IU$ (i.e., D outsources to I but I outsources to U), then I outsources q_I to U to meet its own demand; in addition, it also orders q_D from U to fulfill the demand of D. Therefore, total quantity ordered from U is $X = q_I + q_D = Q$. Let $q = (q_I, q_D)$. Payoffs for each firm at the terminal nodes are $\pi_k^\delta, k = I, D$, given by

$$\begin{aligned}
(\pi_I^{II}(p_I; q), \pi_D^{II}(p_I; q)) &= (P(Q)q_I - C_I(Q) + p_I q_D, P(Q)q_D - p_I q_D) \\
(\pi_I^{IU}(v; q), \pi_D^{IU}(v; q)) &= (P(Q)q_I - C_I(q_I), P(Q)q_D - v(q_D)q_D) \\
(\pi_I^{UU}(v; q), \pi_D^{UU}(v; q)) &= (P(Q)q_I - v(Q)q_I, P(Q)q_D - v(Q)q_D) \\
(\pi_I^{UI}(p_I, v; q), \pi_D^{UI}(p_I, v; q)) &= (P(Q)q_I - v(Q)Q + p_I q_D, P(Q)q_D - p_I q_D)
\end{aligned}$$

Our main result to game G asserts that if the cost disadvantage of U is not too significant (i.e. λ is not too large), then both I and D outsourcing to U is the unique SPNE outsourcing regime. The main result is also summarized in Figure 1 below, in which λ is varied on the horizontal axis.

The Main Result *There is a threshold $\theta \in (1, \bar{\lambda}]$ such that if $\lambda \in [1, \theta)$, then in any SPNE, both I and D orders α exclusively from U.*

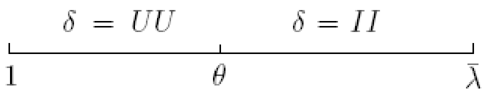

Figure 1: SPNE Outsourcing Regime

[6]The exclusivity can be justified on the ground that intermediate goods produced by different providers might be specialized, making it infeasible for the final-good producer to use multiple sources of intermediate goods in the same production process. Moreover, there can be negotiation cost in the transaction for the intermediate good.

[7]This assumption is meant to simplify the analysis. Our essential finding will not be affected if U is an upstream monopolist and thus can strategically determine its price for good α.

Observe that when $\lambda \in (1, \theta)$, U has a cost disadvantage compared to I, yet both I and D outsource α to U rather than to I. Strategic considerations dominate firms' behavior here. This confirms our claim that outsourcing to offshore locations can persist due to strategic effect of scale economies, even if offshore costs rise moderately as long as offshore producers abstain from the final good markets.

3 Model Analysis

In this section, we shall first characterize the SPNE of game G. Its proof is derived after we illustrate the procedure of backward induction to solve the game.

3.1 SPNE of Game G: The Detailed Characterization

Before we fully characterize SPNE of game G, it is useful to define θ:

$$\theta \equiv \min(\bar{\lambda}, \tilde{\lambda}),$$

where $\tilde{\lambda}$ is defined below. It is also useful to define $\hat{\lambda}$:

$$\tilde{\lambda} \equiv \frac{A - B\sqrt{49 - 52c}}{2b(52c^2 - 105c + 54)}, \quad \hat{\lambda} \equiv \frac{a(3 - 4c) + Z\sqrt{1 - c}}{b(3 - 4c + 3\sqrt{1 - c})},$$

with $A = a(80c^2 - 144c + 63) + b(24c^2 - 66c + 45), B = (3 - 2c)(3 - 4c)(a - b), Z = 2b(3 - 2c) - a(3 - 4c)$. We have $1 < \tilde{\lambda} < \hat{\lambda}$. If c is not very close to $1/2$, then $\hat{\lambda} < \bar{\lambda}$.

Price of U can take two values in SPNE, $\bar{v}$ and $\underline{v}$, defined as

$$\bar{v} \equiv \frac{b\lambda(3 - 4c) - c(a + b - 2ac)}{3 - 6c + 2c^2}, \quad \underline{v} \equiv \frac{3b\lambda - 2ac}{3 - 2c}.$$

Also define function $\bar{p}_I(v)$ as

$$\bar{p}_I(v) \equiv \frac{3 - 2c}{3 - 4c}v - \frac{(a + b - 2ac)c}{(3 - 4c)(1 - c)}.$$

Define I's monopoly price as $p^M \equiv \frac{a+b-2ac}{2(1-c)} < a$. We have $p^M > \bar{v} > \underline{v} > 0$, and $\bar{p}_I(v) < v$ for $v < p^M$.

Theorem 1 *SPNE of game G is characterized below.*

(I) For $\lambda \in [1, \theta)$, $\delta = UU$ is the unique SPNE outsourcing regime. In any SPNE, $v = \underline{v}, p_I \geq \underline{v}$.

(II) For $\lambda \in (\theta, \bar{\lambda})$, $\delta = II$ is the unique SPNE outsourcing regime. Moreover, $(v, p_I) = (\bar{v}, \bar{p}_I(\bar{v}))$ if $\lambda > \hat{\lambda}$, $(v, p_I) = (\underline{v}, \bar{p}_I(\underline{v}))$ if $\lambda < \hat{\lambda}$, and (v, p_I) is either $(\bar{v}, \bar{p}_I(\bar{v}))$ or $(\underline{v}, \bar{p}_I(\underline{v}))$ at $\lambda = \hat{\lambda}$.

(III) If $\tilde{\lambda} < \bar{\lambda}$ (i.e. $\theta = \tilde{\lambda}$), two outsourcing regimes can arise in SPNE at $\lambda = \theta$: either $\delta = UU$ with $v = \underline{v}, p_I \geq \underline{v}$; or $\delta = II$ with $(v, p_I) = (\underline{v}, \bar{p}_I(\underline{v}))$.

Proof: Proof is in the following subsection. ∎

When the offshore fringe has cost disadvantage, the existence of SPNE where $\delta = UU$ hinges on the existence of economies of scale. As shown by the following corollary, when the size of scale economies shrinks, so does the range of λ where both I and D outsource to U. The intuition is as follows. Since U is less efficient, the smaller the economies of scale, the more inclined D is to outsource to I: first, D becomes less concerned about the competitive edge I can acquire through supplying D; second, there can be a larger efficiency gain. As a result, in SPNE the range of λ is larger where D orders from I and I produces in-house.

Corollary 1 *$\theta \to 1$ when $c \to 0$.*

Proof: It follows by noticing that $\lim_{c\to 0} \bar{\lambda} = \frac{a+b}{2b} > 1$ and $\lim_{c\to 0} \tilde{\lambda} = 1$. ∎

3.2 Proof of Theorem 1

In order to derive proof of Theorem 1, we first do backward induction to solve game G. We start from the quantity decisions in stage three for given outsourcing regimes.

The values of (p_I, v) relevant are such that in equilibrium both I and D produce positive quantities for β, given by $p_I < p^M, v < p^M$. There exists a unique Cournot equilibrium $(q_I^\delta(p_I, v), q_D^\delta(p_I, v))$ in each outsourcing regime δ (details are given in Appendix). The corresponding equilibrium payoffs are

$$\begin{aligned}
&(\pi_I^{II}(p_I), \pi_D^{II}(p_I)) = ([q_I^{II}(p_I) + q_D^{II}(p_I)]^2 H - [q_D^{II}(p_I)]^2, [q_D^{II}(p_I)]^2);\\
&(\pi_I^{IU}(v), \pi_D^{IU}(v)) = ([q_I^{IU}(v)]^2(1-c), [q_D^{IU}(v)]^2);\\
&(\pi_I^{UU}(v), \pi_D^{UU}(v)) = ([q_I^{UU}(v)]^2, [q_D^{UU}(v)]^2);\\
&(\pi_I^{UI}(p_I, v), \pi_D^{UI}(p_I, v)) = ([q_I^{UI}(p_I, v)]^2 + (p_I - v)q_D^{UI}(p_I, v), [q_D^{UI}(p_I, v)]^2).
\end{aligned} \tag{4}$$

Here $H \equiv \frac{a+bc-2b+(1-c)p_I}{2a-b-p_I}$. The following lemma follows direct calculation and is intuitive: when I produces in-house and D outsources to I, I prefers to charge p_I for D as high as possible for profit from the upstream market as well as raising rival's cost.

Lemma 1 *$\frac{d\pi_I^{II}(p_I)}{dp_I} > 0$ for $p_I \in (0, p^M)$.*

We move back to stage two. At given value v, when I produces in-house, there exists a threshold value of p_I given by $\bar{p}_I(v)$. If and only if $p_I < \bar{p}_I(v)$, D strictly prefers ordering from I to ordering from U. Notice that $\bar{p}_I(v) < v$, implying that if I produces in-house, D will order from I if and only if p_I is sufficiently lower than v. The following lemma follows direct calculation.

Lemma 2 *$\pi_D^{II}(p_I) \gtreqless \pi_D^{IU}(v)$ for $p_I \lesseqgtr \bar{p}_I(v)$.*

We move back to stage one, where I and U compete in prices for supplying α. Let us first rule out a trivial equilibrium. When $p_I = v$, given that I outsources to U, D is indifferent between ordering from I or from U, and it can occur that D orders from I. It thus can arise in equilibrium that $p_I = v$, followed by $\delta = UI$. However, this equilibrium in essence is $\delta = UU$. To avoid this trivial equilibrium, we treat any SPNE with $p_I = v$ followed by $\delta = UI$ as $\delta = UU$.[8]

We have several major findings to the price competition in stage one. First, it can be shown that, whenever $p_I \neq v$, $\delta = UI$ can not be in any SPNE. Hence in equilibrium, U supplies positive quantity only in outsourcing regime UU or IU. If outsourcing regime is IU, U's price v is solved from $v = AC(q_D^{IU}(v))$ as $\bar{v}$; if outsourcing regime is UU, v is solved from $v = AC(q_I^{UU}(v) + q_D^{UU}(v))$ as $\underline{v}$. Second, given that $p_I = \bar{p}_I(v)$, at either $v = \bar{v}$ or $v = \underline{v}$, I is better off also supplying D whenever I produces in-house to meet its own demand of α. In other words, I always prefers regime II to IU. Third, given that $v = \underline{v}$ and D outsources to U, I strictly prefers regime UU to IU only if the cost disadvantage of U is not too big, i.e., $\lambda < \hat{\lambda}$. Finally, comparing regimes II and UU for I under $(p_I, v) = (\bar{p}_I(\underline{v}), \underline{v})$, we find that I strictly prefers regime UU to II only if $\lambda < \tilde{\lambda}$. The following lemma summarizes the major findings to stage one.

Lemma 3 *(a) In any SPNE, it can not be $p_I \neq v$ and $\delta = UI$.*

(b) $\pi_I^{II}(\bar{p}_I(\bar{v})) > \pi_I^{IU}(\bar{v})$; $\pi_I^{II}(\bar{p}_I(\underline{v})) \geq \pi_I^{IU}(\underline{v})$ with equality holds only at $\lambda = 1$.

(c) If $\hat{\lambda} < \bar{\lambda}$, then $\pi_I^{UU}(\underline{v}) \gtreqless \pi_I^{IU}(\underline{v})$ for $\lambda \lesseqgtr \hat{\lambda}$. Otherwise $\pi_I^{UU}(\underline{v}) > \pi_I^{IU}(\underline{v})$.

(d) If $\hat{\lambda} < \bar{\lambda}$, then $v = \underline{v}$ for $\lambda < \hat{\lambda}$, $v = \bar{v}$ for $\lambda > \hat{\lambda}$, either $v = \underline{v}$ or $v = \bar{v}$ at $\lambda = \hat{\lambda}$. Otherwise $v = \underline{v}$.

(e) If $\tilde{\lambda} < \bar{\lambda}$, then $\pi_I^{UU}(\underline{v}) \gtreqless \pi_I^{II}(\bar{p}_I(\underline{v}))$ for $\lambda \lesseqgtr \tilde{\lambda}$. Otherwise $\pi_I^{UU}(\underline{v}) > \pi_I^{II}(\bar{p}_I(\underline{v}))$.

Proof: (a) Suppose not. Given $\delta_I = U$, if D deviates from $\delta_D = I$ to $\delta_D = U$, its profit changes from $\pi_D^{UI}(p_I, v)$ to $\pi_D^{UU}(v)$. For D to have no incentive to deviate, it must be $p_I < v$ by (4). However, again by (4), I will deviate to $p_I = v$ followed by $\delta_I = U$, since its profit is larger in this case no matter $\delta_D = I$ or $\delta_D = U$. A contradiction.

(b), (c), (e) follows direct calculation. (d) follows (c) and the perfect competition in upstream fringe. ∎

We are now ready to give proof of Theorem 1. Since proof of parts (I), (II) and (III) are similar, we only gives proof of (I) in Theorem 1.

Proof of Theorem 1 (I) Step one. We show that given $v = \underline{v}, p_I \geq \underline{v}$, $\delta = UU$ is in SPNE. Given $\delta_I = U$, if D deviates from $\delta_D = U$ to $\delta_D = I$, its profit changes from $\pi_D^{UU}(\underline{v})$ to $\pi_D^{UI}(p_I)$. By (4), D is no better off for $p_I = \underline{v}$ and is worse off for $p_I > \underline{v}$. Thus D will not deviate. On the other side, given $\delta_D = U$, if I deviates from $\delta_I = U$ to $\delta_I = I$, its profit changes from $\pi_I^{UU}(\underline{v})$ to $\pi_D^{IU}(p_I)$. By Lemma 3(c), it is worse off since $\lambda < \min(\bar{\lambda}, \tilde{\lambda}) < \hat{\lambda}$. I will not deviate either. Thus $\delta = UU$ is in SPNE.

Step two. We show that $v = \underline{v}, p_I \geq \underline{v}$ is in SPNE. By Lemma 3(d), $v = \underline{v}$. We need to check if I has incentive to deviate to $p_I < \underline{v}$. Suppose it deviates. Then in stage two, $\delta = UU$ can not arise since by (4), D will deviate from $\delta_D = U$ to $\delta_D = I$. Moreover, $\delta = IU$ can not arise since by Lemma 3(c), I is profitable deviating from $\delta_I = I$ to $\delta_I = U$. Suppose $\delta = UI$ in stage two. By (4), I is strictly worse off under UI than under UU. Hence I will not deviate to $p_I < \underline{v}$ for $\delta = UI$. Suppose $\delta = II$ in stage two. By Lemma 2, it can be

[8] Assuming the existence of some transaction cost for I to supply D can break the tie and make any SPNE with $p_I = v$ followed by $\delta = UI$ disappear.

the case only if $p_I \leq \bar{p}_I(\underline{v})$, otherwise D will deviate from $\delta_D = I$ to $\delta_D = U$. However, by Lemma 3(e) and Lemma 1, I is strictly worse off. Thus I will not deviate to $p_I < \underline{v}$ for $\delta = II$ either. We conclude that under no circumstance will I deviates to $p_I < \underline{v}$.

Step three. We show that there does not exist other SPNE. First, $v = \underline{v}$ by Lemma 3(d). Second, by Lemma 3(a), $\delta = UI$ is off-equilibrium. Third, for $\lambda < \hat{\lambda}$, by Lemma 3(c), $\delta = IU$ is off-equilibrium. Fourth, suppose in some SPNE $\delta = II$. By Lemma 2, it must be $p_I \leq \bar{p}_I(\underline{v}) < \underline{v}$. However, I is profitable deviating to $p_I' > \underline{v}$. By doing so, by step one, Lemma 2, Lemma 3(a) and (c), it must be $\delta = UU$ in stage two. Then by Lemma 3(e), I is strictly better off. A contradiction. II can not be in SPNE. Last, suppose in some SPNE $\delta = UU$ with $p_I < \underline{v}$. However, by (4), D will deviate to $\delta_D = I$, again a contradiction. We conclude that there does not exist SPNE other than $v = \underline{v}, p_I \geq \underline{v}$, followed by $\delta = UU$. ■

4 Discussion and Conclusion

We show that the strategic effect of scale economies can drive both integrated and disintegrated downstream firms to outsource offshore for intermediate goods, even if there is modest cost disadvantage with offshore providers in producing the intermediate goods. The reason is, under economies of scale in upstream production, disintegrated downstream firm tends to purchase intermediate goods from offshore pure provider rather than its vertically integrated rival. Then driven by the incentive to exploit scale economies, vertically integrated firm will give up in-house production and also outsource offshore.

In our setting, the existence of offshore competitive fringe sustains a duopoly market for the final good β and consumers are almost always better off. Without the fringe, the integrated firm I will charge a high price for good α to drive firm D out of the market, then produce in-house good α as a monopolist. If so, its monopoly quantity of good β is given by $a - p^M = (a-b)/2(1-c)$. As long as $\lambda < \bar{\lambda}$, the emergence of offshore fringe ensures that both I and D are active in the market β. If the cost disadvantage of U is relatively big (i.e. $\lambda \in (\theta, \bar{\lambda})$) so that in equilibrium $\delta = II$ (both I and D orders good α from I), it is verifiable that the duopoly quantity is always larger than the monopoly quantity, hence consumers are better off. In this case, production is also efficient since the low-cost firm I supplies good α. If the cost disadvantage of U is modest (i.e. $\lambda \in [1, \theta)$) such that in equilibrium $\delta = UU$ (both I and D orders good α from U), the duopoly quantity is almost always larger than the monopoly quantity. We find that, exception occurs only in extreme cases where c is very close to 1/2 and λ is very close to the corresponding θ.[9]

Although we exogenously assume the exclusivity in downstream firms' sourcing mode throughout our analysis, exclusivity can arise endogenously due to scale economies in upstream production technology. Moreover, our model can be extended to including two or

[9]For example, suppose $a = 10, b = 9.5$. By (3), the upper bound of c is 0.475. For $c < 0.4473$, the duopoly quantity under $\delta = UU$ is always larger than the monopoly quantity. Let $c = 0.47$, then $\theta = \min\{\bar{\lambda}, \tilde{\lambda}\} = 1.0025$. Then for $\lambda < 1.0015$, the duopoly quantity under $\delta = UU$ is larger than the monopoly quantity. The reverse is true for $\lambda > 1.0015$. The intuition is as follows. When $\delta = UU$ with c very close to $\frac{1}{2}$ and λ very close to its upper bound θ, two effects result in a smaller duopoly quantity than the monopoly quantity. On the one side, since U has a relatively large cost disadvantage, it charges a high price of good α for the downstream duopolists, leading to a relatively small duopoly quantity. On the other side, since I faces large scale economies when it produces in-house as a monopolist, it produces a relatively large monopoly quantity in order to better exploit economies of scale.

more downstream disintegrated firms, which will strengthen the strategic effect of scale economies in driving downstream competitors to outsource offshore. In the type-symmetric pure strategy equilibrium, all these disintegrated firms order from the offshore pure supplier, which further drives down the supplier's average cost hence also its price of α, making the integrated firm to be more willingly outsource offshore.

Our results are derived under downstream quantity competition with homogeneous products. One concern is to what extent our results carry over price competition. Suppose firms I and D produce heterogeneous good β and decide their prices in stage three. Literature shows that, in context of price competition and linear production cost, strategic consideration can lead firm D to favor firm I for the supply of good α. The reason is, when I is making profit in the market α by supplying D, I has less incentive to lower its price for good β because aggressive pricing will reduce D's sale hence hurt I's profit in the market α. (see Chen (2001); Chen et al. (2004); Arya et al. (2008b)). Here with economies of scale in the production of α, D's outsourcing to I imposes two opposite effects on the competition in the market β. On the one side, it gives I a competitive edge on account of economies of scale, making I more aggressive. On the other side, it creates the strategic incentive for I to soften downstream price competition, as identified in Chen (2001), making I less aggressive. Nevertheless, we find that, as long as the cost disadvantage of the offshore fringe is not too big, the first effect can dominate. With price competition, it again occurs that, in equilibrium both I and D outsource to the offshore fringe for good α even if the offshore provider has a modest cost disadvantage.

Appendix

When both firms I and D are active in the market β, their Cournot quantities in stage three for each outsourcing regime are given below. After that, two observations are listed out, which shows that in SPNE, upstream prices (p_I, v) indeed lead to positive quantities produced by I and D. Note that $p^M > \frac{2b-a-2ac}{1-2c}$ and $p^M > 2b-a$.

a. $\delta = II$. If $p_I \in (\frac{2b-a-2ac}{1-2c}, p^M)$, Cournot quantity for each firm is positive, given by

$$q_I^{II}(p_I) = \frac{a+2ac-2b+(1-2c)p_I}{3-2c}, q_D^{II}(p_I) = \frac{a+b-2ac-2(1-c)p_I}{3-2c}.$$

b. $\delta = IU$. If $v \in (2b-a, p^M)$, Cournot quantity for each firm is positive, given by

$$q_I^{IU}(v) = \frac{a-2b+v}{3-4c}, q_D^{IU}(v) = \frac{a+b-2ac-2(1-c)v}{3-4c}.$$

c. $\delta = UU$. For $v < a$, Cournot quantity is positive for each firm, given by

$$q_I^{UU}(v) = q_D^{UU}(v) = \frac{a-v}{3}.$$

d. $\delta = UI$. For $a + p_I > 2v, a + v > 2p_I$, Cournot quantity of each firm is positive, given by

$$q_I^{UI}(v, p_D) = \frac{a+p_I-2v}{3}, q_D^{UI}(v, p_D) = \frac{a+v-2p_I}{3}.$$

Observation 1 $\bar{v} > 2b-a$; $p^M > \bar{v} > \underline{v} > 0$.

Observation 2 $\bar{p}_I(\bar{v}), \bar{p}_I(\underline{v}) \in (\frac{2b-a-2ac}{1-2c}, p^M)$.

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