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Economies of Scale and (Non)Existence of Strategic Outsourcing in Cournot Duopoly

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Abstract

In the presence of economies of scale, the existence of strategic outsourcing equilibrium in a Cournot duopoly market crucially depends on the existence of input market. We show that when an input market exists with the input supplier charging an appropriate price for the input, the strategic outsourcing equilibrium exists for some values of the parameters. However, if the input supplier and the final good producers all have an identical technology for input production, the paper shows that no strategic outsourcing equilibrium exists and the market becomes either a duopoly or a monopoly with vertically integrated production process.

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1. Introduction

Of late, some researchers have analysed how the outsourcing of input as opposed to in-house production can be used as a strategic tool to take advantage in the oligopolistic final good market. Nickerson and Vanden Bergh (1999) considered a Cournot duopoly competition in the product market and analysed the organizational form adopted by firms when outsourcing from the input market involves a higher per unit cost of input due to mark-up. Shy and Stenbacka (2003) have considered the strategic outsourcing versus in-house production in Hotelling differentiated product model under price competition between two final good producers and showed that even when the subcontractor is a monopolist in the input market, in the presence of economies of scale both firms would choose to outsource the input production to a common input producer for some parameter values. Buehler and Haucap (2006) considered non-specific inputs required for final good production and established the possibility of equilibrium where outsourcing is done either by both firms or by one firm. Many studies have emphasised the role of economies of scale and argued that the economies of scale increases the incentive for outsourcing input production to common input suppliers (for instance, see Cachon and Harker 2002, Alexandrov 2010).[1]

We consider a setting with two final good producers competing *a la* Cournot by choosing quantities. There exists an independent input supplier who does not have the technology to produce the final product. All three firms have the identical input production technology involving a fixed set up cost and a constant marginal cost of production. In this setting we analyse the decisions of two final good producers between outsourcing from the independent input supplier and producing inputs in-house. We show that there does not exist any equilibrium where input is outsourced from the input supplier. There will be in-house production of inputs and the market structure will be either a duopoly or a monopoly with vertically integrated production process. Thus, this result is in contrast with Shy and Stenbacka (2003). Our result is also different from Nickerson and Vanden Bergh (1999) and Buehler and Haucap (2006) where the existence of input suppliers are assumed without paying due attention to the fixed cost component of such input production technology.

2. The Model

Let firm 0 be an independent input supplier. Firm 1 and firm 2 are final good producers having an identical technology to produce a homogeneous good which requires a non-specific key input and they compete a la Cournot in the product market. Firm 1 and 2 also possess input production technology which is the same as that of firm 0. The input production is subject to economies of scale.

For simplicity, we assume that one unit of the key input is required to produce one unit of the final good, and no other input is required. Consider a linear market demand (in inverted form) for the final good,

$$P = Max\{0, a-(q_1+q_2)\}, \tag{1}$$

where P is the price of the product and q_i is the supply of the i-th firm, $i = 1, 2$.

We consider the following three-sage game.

[1] Moreover, there are some interesting contributions on strategic outsourcing. See, Chen 2011, Arya *et al.* 2008, Kabiraj and Sinha 2014 and so on.

Stage 1: Both firms 1 and 2 simultaneously decide whether to produce input in-house or outsource from firm 0. For in-house production, the firm incurs a fixed cost for setting up an input production division. For outsourcing, the firm does not invest in input production division.

Stage 2: Firm 0 decides whether to set up the input production facility or not. In case it sets up the production facility then it chooses the price of input based on the market demand coming from the final good producer(s).

Stage 3: Firms 1 and 2 compete in quantities in the final good market.

There is a fixed investment, F, required in setting up the input production facility and subsequently a constant marginal cost c is incurred per unit of input production. So for the final good producers the total cost (TC) function for the final good would be

TC = F+cq_i , if in-house production

= w q_i , if outsourcing,

where q_i measures the quantity of firm i for i=1, 2 and *w* is the input price charged by firm 0. We will solve the game by backward induction.

Depending on the first stage decisions of firms 1 and 2 between outsourcing (O) and in-house production (I), we would have four regimes. (i) (O-O); (ii) (O-I); (iii) (I-O); and (iv) (I-I). We first consider the benchmark case where for the independent input supplier the production facility already exists and to meet input demand it does not need to incur any fixed cost of setting up a plant, hence it has F=0.

3. Benchmark case: (F=0 for the input supplier)

Suppose in stage 1 both firms decide to outsource from firm 0. Assume the monopoly price charged by firm 0 is *w*.

O-O regime:

In the third stage of the game under Cournot competition, firm 1 and 2 would produce quantities: $q_1^{O\text{-}O} = q_2^{O\text{-}O} = \frac{(a-w)}{3}$.

The total derived demand for inputs would be $Q^{O\text{-}O} = q_1^{O\text{-}O} + q_2^{O\text{-}O} = \frac{2(a-w)}{3}$

In the second stage, firm 0 would choose w to maximize its profit = $(w-c)\frac{2(a-w)}{3}$.

This yields, $\frac{2}{3}(a-2w+c)=0$

$$\Rightarrow w^{O-O} = \frac{(a+c)}{2}$$

Plugging the value of w^{O-O} we get the profit of firm 0 as:

$$\left(\frac{a+c}{2}-c\right)\frac{2\left(a-\frac{a+c}{2}\right)}{3}=\frac{(a-c)^2}{6}$$

The profit of each of firm 1 and 2 will be: $\frac{(a-c)^2}{36}$.

<u>O-I regime:</u>

Given the input market price the quantity choice in the third stage would be

$q_1^{O-I}=\frac{(a-2w+c)}{3}$

$q_2^{O-I}=\frac{(a-2c+w)}{3}$

Since the demand for input comes only from firm 1, firm 0 would maximize its profit

$(w-c)\frac{(a-2w+c)}{3}$.

This yields the equilibrium input price: $w^{O-I}=\frac{a+3c}{4}$.[2]

So under O-I, the equilibrium quantities are

$q_1^{O-I}=\frac{(a-2(\frac{a+3c}{4})+c)}{3}=\frac{(a-c)}{6}$, $q_2^{O-I}=\frac{(a-2c+(\frac{a+3c}{4}))}{3}=\frac{5(a-c)}{12}$.

Thus, the profit of firm 1 is $\frac{(a-c)^2}{36}$ and the profit of firm 2 is $\frac{25(a-c)^2}{144}-F$.[3]

Firm 0 gets: $\left((\frac{a+3c}{4})-c\right)\frac{\left(a-2(\frac{a+3c}{4})+c\right)}{3}=\frac{(a-c)^2}{24}$.

<u>I-I regime:</u>

In this case there is no demand in the input market. In the third stage of the game the profit is $\frac{(a-c)^2}{9}$ for each firm. Given F>0 for final good producers, the payoff matrix for firm 1 and 2 based on their choice of O and I is.

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[2] Note that the input price would be lower when only one firm outsources than when both firms do.

[3] I-O regime would have symmetrically opposite payoffs for firms 1 and 2.

Firm 1 \ Firm 2	O	I
O	$\frac{(a-c)^2}{36}$ $\frac{(a-c)^2}{36}$	$\frac{(a-c)^2}{36}$ $\frac{25(a-c)^2}{144} - F$
I	$\frac{25(a-c)^2}{144} - F$ $\frac{(a-c)^2}{36}$	$\frac{(a-c)^2}{9} - F$ $\frac{(a-c)^2}{9} - F$

Figure 1: Payoff matrix under different organizational forms.

The in-house production of input for both firms would be profitable if, $\frac{(a-c)^2}{9} - F > 0$ i.e., if $F < \bar{F} \equiv \frac{(a-c)^2}{9}$. For $F \geq \bar{F}$, in-house productions by both final good producers are not profitable. Since F= 0 for the input supplier, firms 1 and 2 can outsource the input from firm 0 irrespective of their own fixed cost of input production (including $F \geq \bar{F}$).

By comparing the subgame perfect Nash equilibrium payoffs under different strategies, it is clear that the outcome would be O-O when $F > \frac{7(a-c)^2}{48}$. [4]

Both final good producers will produce in-house if, $F < \frac{(a-c)^2}{12}$.

The asymmetric equilibrium will occur where one firm would outsource and the other firm will produce the input in-house for $\frac{(a-c)^2}{12} < F < \frac{7(a-c)^2}{48}$. Thus, we have

Proposition 1. *Assuming that the input supplier has an existing input production facility (i.e. F = 0 for the input supplier), we find the following outcome depending on the fixed cost of in-house input production for the final good producers.*

(i) *For* $F \geq \frac{7(a-c)^2}{48}$, *both final good producers would outsource their input production,*

(ii) *for* $\frac{(a-c)^2}{12} < F < \frac{7(a-c)^2}{48}$, *one firm will outsource and the rival will produce the input in-house and*

(iii) *for* $F \leq \frac{(a-c)^2}{12}$, *both firms will produce the input in-house.*

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[4] Note that $\bar{F} < \frac{7(a-c)^2}{48}$.

Diagrammatically,

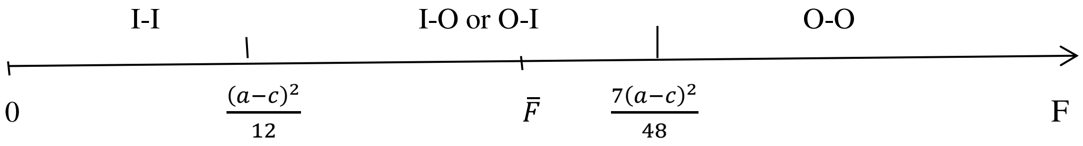

Figure 2: Characterisation of equilibrium when F=0 for input supplier.

4. Identical technology of input production with F>0

Now all firms have the same F>0 for input production. The input supplier also has to choose whether to set up a plant or not in stage 2. Thus, it is not guaranteed that the input supplier would always exist to supply input to the final good producers. If the input supplier chooses not to set up its plant, the final good producers would not receive any input under outsourcing. Taking the profit expressions of firm 0, the following lemma characterises the existence of firm 0.

Lemma 1: *(i) When both firms choose to outsource their inputs from firm 0, firm 0 will operate if* $F < \frac{(a-c)^2}{6}$ *and does not operate otherwise. (ii) When one firm chooses to outsource from firm 0, firm 0 will operate if* $F < \frac{(a-c)^2}{24}$ *and does not operate otherwise.*

Note that for $F < \frac{(a-c)^2}{24}$, firm 0 exists and the payoff matrix remains as given in Figure 1. Thus, both firms will produce input in-house for F $< \frac{(a-c)^2}{24}$. Now for $F \geq \frac{(a-c)^2}{24}$, the input supplier does not exist if only one firm decides to outsource and therefore the outsourcing firm would receive 0 and the firm producing in-house would get the monopoly profit. Using Lemma 1, for $\frac{(a-c)^2}{24} \leq F < \frac{(a-c)^2}{6}$, the payoff matrix becomes:

Firm 1 \ Firm 2	O	I
O	$\frac{(a-c)^2}{36}$ $\frac{(a-c)^2}{36}$	0 $\frac{(a-c)^2}{4} - F$
I	$\frac{(a-c)^2}{4} - F$ 0	$\frac{(a-c)^2}{9} - F$ $\frac{(a-c)^2}{9} - F$

Figure 3. Payoff matrix for $\frac{(a-c)^2}{24} \leq F < \frac{(a-c)^2}{6}$.

We observe that I-I equilibrium would occur if $F < \frac{(a-c)^2}{9}$. It is also clear that for, $\frac{(a-c)^2}{9} < F < \frac{(a-c)^2}{6} < \frac{2(a-c)^2}{9}$, it would be monopoly of a firm and O-O equilibrium is not possible.

For the last possibility F> $\frac{(a-c)^2}{6}$, the input supplier does not exist and the payoff from outsourcing yields 0 payoffs for both firms (the modified payoff matrix in Fig. 3 would have (0, 0) payoff with respect to O-O choice). Thus, for $F > \frac{(a-c)^2}{6}$, only one firm exists in the market by producing the input in-house. The existence of one vertically integrated firm is possible until the point its payoff remains positive i.e., $F < \frac{(a-c)^2}{4}$. Hence,

Proposition 2. *With identical input production technology subject to economies of scale there does not exist any outsourcing equilibrium. The equilibrium involves in-house production by both firms whenever* $F < \frac{(a-c)^2}{9}$, *whereas for* $\frac{(a-c)^2}{9} < F < \frac{(a-c)^2}{4}$, *there will be monopoly production by one vertically integrated firm.*

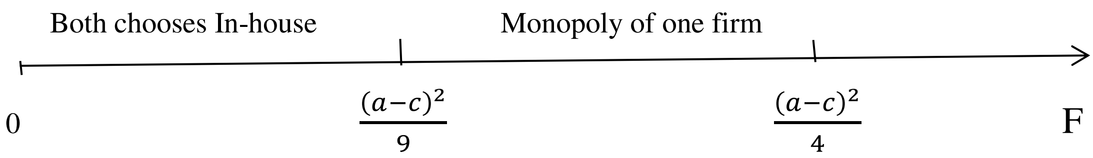

Figure 4. Equilibrium outcome under identical input production technology with economies of scale.

It is important to note that the outsourcing equilibrium does not exist when all three firms have the same input production technology (the same F>0). Combining our result on existence of outsourcing equilibrium described in proposition 1, it is clear that if the input supplier has a different F which is sufficiently low then it is possible to have outsourcing equilibrium in our model.

5. Conclusion

In a homogenous good Cournot duopoly market with an independent input supplier, we have shown that outsourcing equilibrium does not exist when all firms have the same input production technology. This happens even though there is an advantage of undertaking the input production in a single plant due to economies of scale. In terms of governance choice firms will always produce input in-house and the market structure will be either a duopoly or a monopoly with vertically integrated production process depending on whether the fixed cost of setting up input production plant is lower or higher. The crucial point of our analysis is the endogenous choice of input supplier regarding setting up an input production plant.[5] However, the outsourcing equilibrium exists if the independent input supplier has a different technology with sufficiently low fixed cost of production.

[5] This is happening even though the input supplier can charge monopoly price for the input.

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