Offshoring in a Vertically Differentiated Industry

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We examine the profitability of offshoring when quality is costly. Two vertically differentiated firms buy inputs domestically or offshore cheaply from developing countries. When the cost difference is independent of quality, equilibrium quality and profits are unchanged if both offshore. However, if cost difference is declining in quality, offshoring leads to lower (equilibrium) quality and lower profits for both firms. If only one firm can offshore, the profits of that firm increases at the cost of its rival. If the offshoring firm is low (high) quality, equilibrium quality of both firms increase (decline) but this is never an equilibrium when both can offshore.

JEL Classification: F23, L23, L24

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1. Introduction

This paper examines the profitability of offshoring in a vertically differentiated industry. Specifically we analyze the impact of offshoring intermediate inputs by a vertically differentiated duopoly located in an industrially developed country to developing country sources.

Offshoring or international outsourcing is estimated to have led to the transfer of a large number of jobs from developed to developing countries. According to various estimates, U. S. companies sent between 104,000 to 400,000 jobs overseas during

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2000-04, while between 3.3 million to 14 million jobs are at the risk of being sent offshore by 2015 (O’Sullivan and Durfee, 2004). Gorge and Hanley (2004) mention a UK survey which finds that 68 percent of firms offshore at least some services the main motivation being cost reduction.

Studies reveal that the major component of the work done by developing countries consists of routine tasks that replace the more expensive labor of the host country. Head and Ries (2002) conducts a micro level study of international outsourcing in Japan on firm level labor demand. Their empirical results show changes in skills intensities that are consistent with fragmentation of lower-skill activities abroad.

Görzig and Stephan (2002) and Görg and Hanley (2003) using firm level data for Germany and Ireland, respectively, find that outsourcing of material inputs can positively affect firm revenues and profits although the result is less clear for outsourcing of services. These studies, however, do not distinguish domestic outsourcing from international outsourcing. Görg, Hanley and Strobl (2004) find positive productivity gains accruing to exporting firms engaging in the offshoring of material inputs and intermediates while the rewards to services procurement might well be non-existent. This accords with a survey IT specialists mentioned by Gorg and Hanley (2004) where a majority of the respondents claimed that offshored IT work was inferior to that produced in-house while some were of the opinion that the offshoring actually induced a setback to the firm’s production.

Most of the theoretical literature does not explicitly distinguish between domestic and international outsourcing. In Grossman and Helpman (2002), firms decide whether to be vertically integrated or to outsource production of components to specialized producers. There is a trade-off between the costs of running a larger and less specialized organization and costs that arise from searching for a suitable supplier and contracting for input quantities and specifications in an environment of imperfect information. Where the cost advantage and relative bargaining power of specialized component producers is large, outsourcing is more likely to emerge the greater is the substitutability between varieties of final goods. In contrast, when the cost advantage and the bargaining power of these producers is slight, intense competition between final producers favors vertically-integrated firms. Outsourcing may be viable in an industry when costs are moderately sensitive to input characteristics, but not when they are only slightly so.
In Ciliberto and Panzer (2011) there are three types of firms: upstream firms that produce an intermediate good; downstream firms that use primary factors and intermediates to produce a final good; and vertically integrated firms that do both. When the fixed costs for the upstream producers are small relative to those of the downstream producers, vertically integrated firms may outsource part of the production of the intermediate input to specialized upstream firms. When the fixed costs for the upstream producers are large relative to those of the downstream producers, then the industry structure is determined by the ratio of the demand for the final good and the “export” demand for the intermediate inputs. Finally, when the intermediate input is imported, then vertically integrated firms can only exist in equilibrium if the economies of vertical scope are very strong.

Antràs, Garicano and R. H.Esteban (2006) assume that developed countries have a distribution of skills with a higher mean than in developing countries. They propose a model of globalization where the more skilled workers from developed countries undertake the more complex and knowledge intensive tasks while the routine tasks are done by less skilled agents in developing countries. They study the equilibrium of a two-country model (North and South) where agents in different countries can join together in teams leading to better matches for all southern workers but only for the best northern workers. As a result, they show that globalization increases wage inequality in the South but not necessarily in the North.

In this paper, we analyze how offshoring intermediate inputs by vertically differentiated firms in a developed country to developing country sources affects their output quality, prices and profits. We assume that the intermediate goods are cheaper in the developing country but the cost differences is lower for higher levels of input quality – for reasons similar to those advanced by Antràs, Garicano and R. H.Esteban (2006). We assume an unit cost of production that is variable in both input and output quality. Specifically, the cost function in our model has two components: (a) the firm’s internal cost of production that is increasing and convex in output quality and decreasing in input quality – to capture the idea that it is cheaper to produce any given output quality if the input quality is better and (b) a cost of obtaining the input – which sold in developing country markets at a competitive price equal to an unit cost that is linear in input quality. In the first stage, the firms non-cooperatively select input and output qualities and in the second stage compete in prices.
We find that when the difference in unit cost of input quality between the developed and developing countries is the same for all levels of quality, offshoring by the low (high) quality firm raises its profits at the cost of its rival while equilibrium quality increases (declines). When both firms offshore intermediate inputs, equilibrium quality and profits are unchanged. However, if input cost difference is declining in quality, offshoring may lead to lower profits for both firms.

In the standard models of vertical differentiation, the cost of production is usually assumed to be zero (Shaked and Sutton, 1982) or a constant unit cost linear with respect to qualities (Shaked and Sutton, 1983). Under these assumptions, there usually exists an upper bound to the number of firms that may coexist in Nash Equilibrium – depending on the distribution of income - with positive market shares and prices exceeding unit variable costs. Price competition drives their price down to a level where no consumer prefers to buy lower quality products at any price exceeding unit variable cost. Further, for any two qualities, (a) the top quality firm enjoys higher profits and (b) the revenue of both firms increase as the quality of the better product improves.

Motta (1993) examines a two stage game where firms select qualities in period one and prices or quantities in period 2. There is a fixed cost that is increasing in quality and the cost of production in the second stage is zero. In this framework, the low quality is a strategic complement to the high quality while the high quality is a strategic substitute to the low quality. If the low quality firm raises its quality then the marginal profit of the high quality firm goes up giving it an incentive to increase its quality and go for the maximum possible differentiation in quality. On the other hand if the high quality firm increases its quality the marginal profit of the low quality firm falls. - sometimes including a fixed cost of quality. In a model with quality dependent fixed costs, and variable cost independent of quality, Lehmann-Grube (1997) confirms the earlier result that the high-quality firm earns a larger profit in the two-stage quality-price game for any consumer distribution function. Wang (2004) shows that the high-quality advantage may not hold if the unit variable cost of production is dependent on quality. Miyamoto (2014) considers a three stage model where in stage 1 firms choose whether to produce in house or outsource, in stage 2 firms choose quality and in stage 3 they compete in prices. We show that not only outsourcing by both firms but an asymmetric configuration, where the high-
quality firm produces in-house while the low-quality firm outsources, is accepted as a subgame perfect equilibrium outcome.

Few papers have explicitly attempted to incorporate input markets in the context of a vertically differentiated industry. Frascatore (2002), for example, finds that when input quality has upward sloping supply, firms may differentiate equally under Bertrand and Cournot competition.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 describes the no-offshoring equilibrium. The equilibrium under offshoring is described in section 4. Finally, Section 5 concludes the paper.

2. The Model

2.1 The Demand Function

The utility function of the consumer is

\[ U = \theta s - p \]  

where \( s \) is the quality of the product, \( \theta \) is the taste parameter with higher \( \theta \) indicating higher valuation for quality and \( p \) is the price. The consumer buys 1 unit of the good when \( U > 0 \) and 0 units otherwise. It is assumed that \( \theta \) is uniformly distributed with density 1 over the range \( (\theta_1, \theta_2) \), \( \theta_0 > 0, \theta = \theta + 1 \). We make the assumption that there is sufficient but not too much heterogeneity in the market, i.e.,

\[ 2\theta \geq \theta \geq 2\theta \]  

The second inequality is standard (Tirole, 1988), we introduce the first to ensure that there is an interior solution to the quality choice problem (see section 4.1 below).

There are two firms in the market. Firm \( i \) produces a good of quality \( s_i \). Without loss of generality we assume \( s_2 > s_1 \) so that (arbitrarily) one firm produces higher and
one lower quality (see Tirole 1988, Motta 1993).\(^2\) A consumer with taste parameter \(\bar{\theta}\) is indifferent between the two brands when

\[
\bar{\theta} \ s_1 - p_1 = \bar{\theta} \ s_2 - p_2
\]

Hence we may define the critical level of the taste parameter as:

\[
\bar{\theta} = \frac{p_2 - p_1}{s_2 - s_1} = \frac{p_2 - p_1}{\Delta s}
\]

(4)

where \(\Delta s\) is the quality differential. Consumers with higher taste parameters relative to the critical value \(\theta > \bar{\theta}\), purchase the higher quality while those with lower taste parameters \(\theta < \bar{\theta}\) buy the lower quality.

This yields the following demand functions,

\[
D_1(p_1, p_2) = \frac{p_2 - p_1}{\Delta s} - \theta
\]

\[
D_2(p_1, p_2) = \bar{\theta} - \frac{p_2 - p_1}{\Delta s}
\]

(5)

Note that in representing the demand functions by (5) we assume that all consumers buy the product, i.e., the market is covered (see for example Tirole, 1988, p. 296). This requires the assumption that:

\[
\frac{2c_1(s_1, r_1) + c_2(s_2, r_2) + (\bar{\theta} - 2\theta)\Delta s}{3} \leq \theta_{S_1}
\]

(6)

This is made to simplify the analysis, as the alternative would make it difficult to obtain closed form solutions for optimum quality choices for the two firms. The

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\(^2\) Since with identical sourcing of inputs both firms obtain the same profits in equilibrium, it does not matter who chooses the higher and who the lower quality.
possible consequence of this assumption on our results is discussed in Section 4.1 below.

2.2 The Cost Function

The marginal cost of production is constant with respect to output, but varying with respect to the quality of output and the intermediate input as well as the source of the input which influences its price. For the moment we shall assume the cost per unit of output to be

\[ C_i = c_i(s, r) \]  

(7)

where \( c_{is} > 0, c_{ir} < 0 \) so that higher output quality raises cost, but higher input quality lowers it.

We now provide a more detailed description of the cost structure of the firm. As indicated earlier, it is assumed that while higher output quality raises costs, better input quality leads to a cost reduction for a given output quality. One unit of the input is required per unit of output. Further, we assume that the marginal cost of the input is constant and a linear function of input quality. Finally, it is assumed that the input is produced in a competitive market so that it is priced competitively, i.e., at marginal cost. Thus the unit cost of production of the final producer(s) has three components:

1. an **internal cost of quality** that is increasing and convex (Lemma 1) in output quality and decreasing in input quality that is the same for both firms

   \[ c(s, r), \quad c_s > 0, c_{ss} > 0, c_r < 0 \]

2. a **cost of input quality** that depends (linearly) on the source of the input

   \[ k_i(r), \quad k_{ir} > 0 \]

3. Finally, there is a component of unit cost unrelated to quality which may be firm-specific, \( b_i \)
Thus the cost structure is:

\[ c_i(s, r) = c(s, r) + k_i(r) + b_i, \ c_s > 0, c_{sx} > 0, c_r < 0, k_{ir} > 0 \]  \hspace{1cm} (8)

To obtain closed form solutions we also assume that the cost function is \(^3\):

\[ c_i(s, r) = c^2 \frac{s^4}{r} + k_i^2 r + b_i \]  \hspace{1cm} (9)

where \( c^2 \) is an internal quality cost parameter, \( k_i^2 \) may be thought of as the unit cost of quality and \( b_i \) the unit cost independent of quality.

2.3 The Stage II Game

In the first stage, the firms non cooperatively select input and output qualities. In the second stage, they compete in prices. As usual, the game is solved by a process of backward induction so we first look at the Stage II game.

Once the firms have made their choice of (output and input) qualities, \( s_i \) and \( r_i \) in stage I, they choose prices \( p_i \) to maximize their Nash equilibrium profits in stage I, where

\[ \Pi_i = (p_i - c_i(s_i, r_i))D_i(p_i, p_j) \]  \hspace{1cm} (10)

Given our assumptions regarding the structure of demand, the firms maximize:

\[ \Pi_1 = (p_1 - c_1(s_1, r_1))\left(\frac{p_2 - p_1}{\Delta s} - \bar{\theta}\right) \]  \hspace{1cm} (11a)

\[ \Pi_2 = (p_2 - c_2(s_2, r_2))\left(\bar{\theta} - \frac{p_2 - p_1}{\Delta s}\right) \]  \hspace{1cm} (11b)

\(^3\) However, the specific form of the cost function does not affect our results as long (8) is satisfied. For example, it is easy to verify that substantially the same results are obtained if the power of \( s \) in the first term (the internal cost function) is changed as long as it is greater than the power of \( r \) in the denominator.
From the first order conditions of maximum, the reaction functions of the firms are:

\[ p_1^* = R_1(p_2) = \frac{p_2 + c_1(s_1, r_1) - \theta \Delta s}{2} \]  
(12a)

\[ p_2^* = R_2(p_1) = \frac{p_1 + c_2(s_2, r_2) + \bar{\theta} \Delta s}{2} \]  
(12b)

Solving for the Nash equilibrium prices \( p_1 \) and \( p_2 \) from (12a) and (12b) we obtain;

\[ p_1^* = \frac{2c_1(s_1, r_1) + c_2(s_2, r_2) + (\bar{\theta} - 2\theta) \Delta s}{3} \]  
(13a)

\[ p_2^* = \frac{c_1(s_1, r_1) + 2c_2(s_2, r_2) + (2\bar{\theta} - \theta) \Delta s}{3} \]  
(13b)

Note that prices are (a) strategic complements, and (b) increasing in unit (marginal) costs. Further, (c) since cost is increasing in quality, it must be true (in equilibrium) that \( c_2(s_2, r_2) > c_1(s_1, r_1) \) and \( p_1 > p_2 \), i.e the unit cost and price of the high quality good is higher than the low quality good. Finally (d) prices are increasing in the quality differential.

Substituting (13a) and (13b) in (11a) and (11b) the stage II profits of the two firms are:

\[ \Pi_1 = \frac{1}{9\Delta s} \left[ (\bar{\theta} - 2\theta) \Delta s + \{c_2(s_2, r_2) - c_1(s_1, r_1)\} \right]^3 \]  
(14a)

\[ \Pi_2 = \frac{1}{9\Delta s} \left[ (2\bar{\theta} - \theta) \Delta s - \{c_2(s_2, r_2) - c_1(s_1, r_1)\} \right]^3 \]  
(14b)

Note that firm profits are decreasing in own costs, and increasing in rival’s costs.
2.4 The Stage I game

In stage I, the firms choose their optimal output and input qualities $s_i$ and $r_i$ to maximize profits $\Pi_i$ as given by (14a) and (14b). From the first order conditions of maximum (assuming interior solutions) we obtain:

\begin{align}
    s_1: \quad & c_2(s_2, r_2) - c_1(s_1, r_1) = \Delta s \left(2 \frac{\partial c_1(s_1, r_1)}{\partial s_1} + (\bar{\theta} - 2\theta) \right) \tag{15a} \\
    s_2: \quad & c_2(s_2, r_2) - c_1(s_1, r_1) = \Delta s \left(2 \frac{\partial c_2(s_2, r_2)}{\partial s_2} - (2\bar{\theta} - \theta) \right) \tag{15b} \\
    r_1: \quad & \frac{\partial c_1(s_1, r_1)}{\partial r_1} = 0 \tag{15c} \\
    r_2: \quad & \frac{\partial c_2(s_2, r_2)}{\partial r_2} = 0 \tag{15d}
\end{align}

Using the first order conditions of maximum (15c) and (15d) and the specific cost function (9) we have the optimal input quality chosen by the firm as a function of its optimal quality of output:

\begin{equation}
    r_i = \frac{c_i}{k_i} s_i^2 \quad i = 1, 2 \tag{16}
\end{equation}

Substituting (15) into the cost function (9) we have the reduced form cost function of the firm,

\begin{equation}
    c_i(s_i, r_i) = 2ck_i s_i^2 + b_i \quad i = 1, 2 \tag{17}
\end{equation}

Verify that when both the slopes and intercepts of the cost functions of the two firms are allowed to be different, we have, using (15a) and (15b)
\[(6ck_1 \Delta k)_1 s_1^* + \frac{1}{2} [3(\bar{\theta} - \bar{\vartheta})k_1 + 2(\bar{\theta} - 2\vartheta)\Delta k]s_1^* = \frac{3(\bar{\theta} - \theta)(-\bar{\theta} + 5\theta)}{32c} - \Delta b = 0 \]  
(18a)

\[s_2^* = \frac{k_1}{k_2} s_1^* + \frac{3(\bar{\theta} - \theta)}{8ck_2} \]  
(18b)

where \( \Delta k = k_1 - k_2 \) and \( \Delta b = b_2 - b_1 \).

3. Domestic Sourcing of Inputs

We now look at the benchmark case where both firms source their input domestically. Thus the input cost function of both firms is the same:

\[k_1 = k_2 = k_N \quad b_1 = b_2 = b_N \]  
(19)

where, subscript \( N \) indicates that the input market is in the developed country (the North).

In this case it is easy to see that

**Proposition 1:** If both firms purchase their inputs domestically at unit cost \( k_N \), in Nash equilibrium

(i) The optimal input and output quality of both firms and their profits vary negatively with the internal cost of quality parameter \( c \) and the unit cost of input quality \( k_N \) but is independent of cost unrelated to quality \( b \).

(ii) Prices differ by quality and depend additionally on cost unrelated to quality \( b \).

(iii) Profits of both firms are equal

**Proof:** See Appendix.
Intuitively, if the unit cost of input quality \( k_N \) increases the input quality demanded by both firms in (Nash) equilibrium and hence of output quality (given internal quality cost) will decline. The same happens if the internal quality cost parameter \( c \) increases.

If, on the other hand, the unit cost of input quality increases, both firms choose lower output qualities, with the quality of the better firm falling by a greater amount. The production cost, which is increasing and convex in quality consequently falls, thereby bringing down price by an even greater amount as it varies positively with the production cost of both firms (see Equations 13 a and 13b). This leads to a fall in the price cost margin. On the other hand, the number of consumers remains the same as the market is assumed to be covered. Thus profits decline with an increase in \( k_N \).

Consider, however, an increase in the input cost unrelated to quality \( b_N \). This has no effect on the choice of input or output quality. However, it raises overall unit cost and prices by an identical amount. However, as the overall market size remains the same total profits are unaffected.

4. Offshoring

Suppose now that the firms decide to offshore their products from a developing country (the South). This would be true only when input costs are lower in the developing country. We assume that the input cost in the developing country is (i) the component of input cost that does not depend on quality is lower \( b_S < b_N \); (ii) the difference is likely to be smaller at higher levels of quality, \( k_S \geq k_N \). In other words the input cost function when one sources from a developing country has a lower intercept, but also has a higher slope, i.e.,

\[
k_S \geq k_N \quad b_S \leq b_N
\]

The idea is that while the cost of producing inputs is substantially lower in the developing country – particularly at low levels of quality - the difference is lower for higher qualities and may even be reversed. This is because of the relative scarcity of very highly skilled or technically competent workers in developing countries despite the presence of abundant workers with ordinary or low levels of skills.
We consider both the cases: (a) where the (unit) input cost of the developing country has a lower slope than the developed country, i.e.,

\[ k_s = k_N, \quad b_s \leq b_N \]  

and (b) where it has both a lower intercept and higher slope. These are shown in Figure 1.

![Figure 1: Unit (Marginal) Input Cost as a function of Input Quality](image)

In this figure, the topmost line represents unit inputs costs (as a linear function of quality) when the input is sourced from the developed country (the North), the second line parallel to it is the input cost function (sourced from the developing country) that has the same slope \( c_N \) but a lower intercept \( b_S \). The third is the case where the input cost function from the developing country has both a lower intercept and a higher slope \( c_S \). The corresponding output cost functions are shown in Figure 2.
Suppose both firms offshore their product from the same developing country input market—indexed as South (S). Then equations (A1) – (A5) in the appendix are enough to establish that:

**Proposition 2:** Suppose both firms offshore their inputs from the same developing country source Then, in the Nash Equilibrium we have,

(i) If $k_S = k_N$, $b_S \leq b_N$ then unit cost of production and prices are lower for both firms but optimal choice of input or output qualities or firm profits are unaffected.

(ii) If $k_S \geq k_N$, $b_S \leq b_N$ then output and input qualities, unit costs, prices and profits are lower for both firms.

This is shown in Figure 3.
Part (i) of the proposition follows directly from Proposition 1 where it is indicated that a change in the component of unit cost unrelated to quality (which changes the intercept but not the slope of the cost function) does not affect the profits of either firm as prices and costs are equally affected while the market size remains the same.

Part (ii) is more interesting. Observe that while sourcing the input from a developing country lowers the overall cost of firms per unit of the input, it raises cost per unit quality. As already indicated in Proposition 1 using (A1)-(A5), while the decrease in cost unrelated to quality has no effect on profits, the increase in (marginal) cost of quality due to implies that the firms in equilibrium select a lower input and hence output quality. As a result the lowering of cost due to lower input cost is smaller in magnitude than the lowering in price due to the additional impact of lower quality of output. This fall in margins is not matched by an increase in quantity due to the assumption that the market is covered and hence the reduction in profits.

Note that if the market is uncovered, i.e., there are a substantial number of consumers who do not buy even the low quality product at the initial price, the price reduction by the low quality firm may induce them to buy the product. In this case it
is possible that at least the low quality firm may not receive lower profits in the complete offshoring equilibrium. The present analysis, then, is applicable to the extent that the market is initially covered. We argue that this likely to be true in case of a wide variety of durable and non-durable consumers goods where consumers are segmented by their income level but no consumer does without the product.

5. Offshoring by one firm

We now consider the case where only one firm offshores its inputs from the developing country. This is may be either because (a) only one of the firms has the information, contacts and/or infrastructure to realize the cost reductions from outsourcing or because (b) offshoring by one firm turns out to be a Nash equilibrium so that offshoring by one firm would not induce the other to follow suit.

If only one firm chooses to offshore, (18a) implies that the equilibrium choice of quality of firm 1 (the low quality firm) is

\[
s_1^* = \frac{-\frac{1}{2} \left[ 3(\bar{\theta} - \theta) + 2(\bar{\theta} - 2\theta)\Delta k \right] \pm \sqrt{\frac{1}{4} \left[ 3(\bar{\theta} - \theta) + 2(\bar{\theta} - 2\theta)\Delta k \right]^2 + 4.6ck_k\Delta k \left( \frac{3(\bar{\theta} - \theta)(-\bar{\theta} + 5\theta)}{32c} + \Delta b \right)}}{2.6ck_k\Delta k}
\]

(22)

while \( s_2^* \) continues to be given by (18b),

\[
s_2^* = \frac{k_1}{k_2} s_1^* + \frac{3(\bar{\theta} - \theta)}{8ck_2}
\]

where \( \Delta k = k_1 - k_2 \) and \( \Delta b = b_2 - b_1 \). Note that the term within the square root sign is positive and greater than the first term in the numerator as long as \( k_1 \geq k_2, b_1 \geq b_2 \) and \( -\bar{\theta} + 5\theta > 0 \). The only solution to the problem is when the sign preceding the second term is positive which makes the numerator positive.
5.1 Differences in Intercept

First consider the case where only the low quality firm offshores its inputs and the input cost function in the developing country differs from the developed country only in terms of the (lower) intercept. In other words, only the unit of input unrelated to quality differs between the two firms, i.e.,

\[ k_1 = k_2 = k_N, \Delta k = 0, \]
\[ (i) \quad b_1 = b_N < b_2, \]
\[ (ii) \quad b_2 = b_N < b_1, \Delta b = b_2 - b_1 \]

We then have the following result:

**Proposition 3:** Suppose only the low (high) quality firm decides to source its input from the developing country. Then if the input cost function of the developing country has a lower intercept but the same slope as the developed country, as in (23)

(i) the equilibrium input and output qualities of both firms are higher (lower),

(ii) the unit cost of low (high) quality firm that offshores is higher (lower) provided the cost difference is large, i.e.,

\[ |\Delta b| > (\prec) 3(\bar{\theta} - \theta) \left[ \frac{6k_N(\bar{\theta} - \theta) - (\bar{\theta} + 5\theta)}{16c} \right] \]  

While that of its rival – that does not offshore – is always higher (lower).

(iii) the profits of the offshoring firm increases while that of the other decreases if the cost difference (\( \Delta b \)) is small relative to the market size (\( \bar{\theta} - \theta \))

(iv) incomplete offshoring may be an equilibrium when offshoring by one leads to increase in profits of both.

**Proof:** See Appendix

Part (i) embodies the idea that the firm that offshores realizes the advantage by encroaching into the domain of its rival, while its rival surrenders ground. Thus when
the (initially) low quality firm offshores, it raises its quality while the high quality firm withdraws to select a still higher quality. Similarly, when it is the high quality firm that outsources, both firms lower their quality.

Part (ii) is more difficult. For this consider first the case where the lower quality firm offshores. The higher quality firm chooses a higher quality with the same cost function and it is easy to see that its unit cost will rise. As for the low cost firm, there are counteracting effects of a lower unit cost unrelated to quality that arises from offshoring and higher unit costs due to choosing a higher quality. If $\Delta b$ is large, the first effect dominates, otherwise the second. Similar is the case when the high cost firm offshores.

Part (iii) is evident in case of the offshoring firm as it must gain from its decision to source its input from the developing country (or else it would not have done so). It is also clear that the other firm that loses its market share with an unchanged cost structure obtains lower profits. However, this also implies that if there were no infrastructural/institutional obstacles which prevent the ‘other’ firm from offshoring, it would also source its input from the developing country. Under such conditions (i.e., no infrastructural constraints), outsourcing by one firm can never be a Nash equilibrium.

5.2 Difference in both Intercept and Slope

Finally, we consider offshoring by the low quality firm, where the cost of input function in the developing country has a lower intercept as well as a higher slope. In this case we have the following result:

**Proposition 4:** Suppose that the cost of input quality function of the developing country has a lower slope and a higher intercept as the developed country. Then

(a) if only the low (high) quality firm can offshore its input, it will do so if

$$-d b_1 > 2c s_1^2 d k_1 \left( -d b_2 > 2c s_2^2 d k_2 \right)$$

(b) However, under the same conditions the high (low) quality firm will experience a loss in profits so that offshoring by only one firm is never an
equilibrium when both firms have the option to source inputs from developing countries.

Proposition 4(a) simply implies that the firm which has the option to offshore will do so only if the lower “fixed cost” of input quality outweighs the higher “marginal cost”. Proposition 4(b) implies that when this is true, its rival will suffer a loss in profits. Hence when both firms have the option to offshore, offshoring by one firm is never an equilibrium. Proposition 4(a) also implies that the initial tendency towards offshoring is stronger for the low quality firm as $s_1 < s_2$.

6. Conclusion

The key result of this paper is that in a vertically differentiated market, offshoring may not lead to an increase in profits for either firm if input cost is declining in quality. Of course this may not hold for the low quality firm if the market is initially uncovered. We argue that vertical differentiation, quality dependent input costs and market coverage are likely to be valid in a wide range of contexts. And it is likely that these are some of the empirically observed situations where offshoring has led to disappointing outcomes.

Aside from extending the scope to include uncovered markets, the analysis can be extended in different directions. One obvious possibility is to look at the consequences of offshoring on consumer surplus and overall welfare. The other is to examine the impact on offshoring on developing country markets that are not perfectly competitive.

References


**Appendix**

**Proof of Proposition 1**

Using (13a), (13b), (14a), (14b), (16), (17), (18a) and (18b) we have:

\[ s_1 = \frac{-\overline{\theta} + 5\theta}{16ck_N} \quad s_2 = \frac{5\overline{\theta} - \theta}{16ck_N} \]  \hfill (A1)

\[ r_1 = \frac{(-\overline{\theta} + 5\theta)^2}{256ck_N^3} \quad r_2 = \frac{(5\overline{\theta} - \theta)^2}{256ck_N^3} \]  \hfill (A2)

\[ c(s_1, r_1) = \frac{(\overline{\theta} + 5\theta)^2}{128ck_N} + b_N \quad c(s_2, r_2) = \frac{(5\overline{\theta} - \theta)^2}{128ck_N} + b_N \]  \hfill (A3)

\[ p_1 = \frac{(5\overline{\theta} - 7\theta)^2}{128ck_N} + 12\overline{\theta} \theta + b_N \quad p_2 = \frac{(7\overline{\theta} - 5\theta)^2}{128ck_N} + 12\overline{\theta} \theta + b_N \]  \hfill (A3)

\[ \Pi_1 = \frac{(\overline{\theta} - \theta)^3}{32ck_N} \quad \Pi_2 = \frac{(\overline{\theta} - \theta)^3}{32ck_N} \]  \hfill (A4)
\[ \tilde{\vartheta} = \frac{p_2 - p_1}{\Delta s} = \frac{(\tilde{\vartheta} - \vartheta)}{2} \]  \hspace{1cm} (A5)

It is easy to see that (A1) – (A5) ensure that Proposition 1 is satisfied.

**Proof of Proposition 3**

Substituting (23), specifically \( k_1 = k_2 = k_N, \Delta k = k_1 - k_2 = 0 \) in (18a) we have

\[ \frac{1}{2} \left[ 3(\tilde{\vartheta} - \vartheta)k_N \right] s_1 - \frac{3(\tilde{\vartheta} - \vartheta)(-\tilde{\vartheta} + 5\vartheta)}{32c} s_2 - \Delta b = 0 \]  \hspace{1cm} (A6)

It is then easy to verify that:

\[ s_1 = \frac{-\tilde{\vartheta} + 5\vartheta}{16ck_N} + \frac{2\Delta b}{3(\tilde{\vartheta} - \vartheta)k_N} \quad \quad s_2 = \frac{5\tilde{\vartheta} - \vartheta}{16ck_N} + \frac{2\Delta b}{3(\tilde{\vartheta} - \vartheta)k_N} \]  \hspace{1cm} (A7)

\[ r_1 = \left[ \frac{-\tilde{\vartheta} + 5\vartheta}{16ck_N} + \frac{2\Delta b}{3(\tilde{\vartheta} - \vartheta)k_N} \right]^2 \quad \quad r_2 = \left[ \frac{5\tilde{\vartheta} - \vartheta}{16ck_N} + \frac{2\Delta b}{3(\tilde{\vartheta} - \vartheta)k_N} \right]^2 \]  \hspace{1cm} (A8)

which implies part (i). Next, substituting these values in (17) we have

\[ c_1(s_1, r_1) = 2ck_N \left[ \frac{-\tilde{\vartheta} + 5\vartheta}{16ck_N} + \frac{2\Delta b}{3(\tilde{\vartheta} - \vartheta)k_N} \right]^2 + b_N \quad \hspace{1cm} (A9) \]

\[ c_2(s_2, r_2) = 2ck_N \left[ \frac{5\tilde{\vartheta} - \vartheta}{16ck_N} + \frac{2\Delta b}{3(\tilde{\vartheta} - \vartheta)k_N} \right]^2 + b_N \]

an inspection of which proves part (ii). Similarly substituting in (13a) and (13b) we have
Finally substituting \( s_1, s_2 \), and hence \( \Delta s = s_2 - s_1 \) from (A7) and \( c_1(s_1, r_1) \text{ and } c_2(s_2, r_2) \) from (A9) in (14a) and (14b) we obtain,

\[
\Pi_1 = \frac{9(\bar{\theta} - \theta)^2 + 16\Delta bc}{864ck_N(\bar{\theta} - \theta)} - \frac{3(\bar{\theta} - \theta)^3}{32ck_N} + \frac{\Delta b}{3k_N} + \frac{8(\Delta b)^2}{27k_N(\bar{\theta} - \theta)}
\]

\[
\Pi_2 = \frac{9(\bar{\theta} - \theta)^2 - 16\Delta bc}{864ck_N(\bar{\theta} - \theta)} - \frac{3(\bar{\theta} - \theta)^3}{32ck_N} + \frac{\Delta b}{3k_N} + \frac{8(\Delta b)^2}{27k_N(\bar{\theta} - \theta)}
\]

This ensures part (iii). Comparing (A7)-(A11) with (A1)-(A5) and observing that the only thing that changes in equation (24) when it is the high quality firm that offshores, is

\[
b_1 = b_N > b_s = b_2, \quad \Delta b < 0
\]

**Proof of Proposition 4**

From the expression of optimum (stage 2) profits in equations (14a) and (14b) and using the specific form of the cost function in (9) we obtain

\[
\Pi_1^* = \Pi_1(k_1, k_2, b_1, b_2)
\]

\[
= \frac{1}{2k} \left\{ c_2(s_2(k_1, k_2, b_1, b_2))^2 - c_1(s_1(k_1, k_2, b_1, b_2))^2 \right\} + (b_2 - b_1)
\]

\[
\text{subject to } b_1 = b_N > b_s = b_2, \quad \Delta b < 0
\]

\[
(A13)
\]
\[ \Pi_2^* = \Pi_2(k_1, k_2, b_1, b_2) \]

\[
\left(2 \bar{\theta} - \bar{\theta}\right) \left[ s_2(k_1, k_2, b_1, b_2) - s_1(k_1, k_2, b_1, b_2) \right] = -2k_2 \left[ s_2(k_1, k_2, b_1, b_2)^2 - c_1 \left( s_1(k_1, k_2, b_1, b_2) \right)^2 \right] - (b_2 - b_1)
\]

\[
= \frac{9 \left[ s_2(k_1, k_2, b_1, b_2) - s_1(k_1, k_2, b_1, b_2) \right]}{9 \left[ s_2(k_1, k_2, b_1, b_2) - s_1(k_1, k_2, b_1, b_2) \right]}
\]

(A14)

The impact of offshoring by the low quality firm to a developing country - which changes the intercept \((b_1)\) or the cost unrelated to quality as well as the slope \((k_1)\) or the cost of input quality - on both firms can then be approximated by (using the envelope theorem)

\[
d\Pi_1^* = \frac{\delta \Pi_1^*}{\delta k_1} dk_1 + \frac{\delta \Pi_1^*}{\delta b_1} db_1 = - \frac{2cs_2^2dk_1 + db_1}{9(s_2 - s_1)} \tag{A15}
\]

\[
d\Pi_2^* = \frac{\delta \Pi_2^*}{\delta k_1} dk_1 + \frac{\delta \Pi_2^*}{\delta b_1} db_1 = \frac{2cs_1^2dk_1 + db_1}{9(s_2 - s_1)} \tag{A16}
\]

Observe that when the low quality firm offshores to the developing country market,

\[
dk_1 > 0 \quad \text{and} \quad db_1 < 0 \tag{A17}
\]

It is easy to verify that the same is true when the high quality firm offshores except that (i) \(s_2\) replaces \(s_1\) and the signs of the corresponding expressions in (A13) and (A14) are reversed.