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Keywords
outsourcing, uncertainty

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Comments
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March 2004

Abstract

This paper investigates outsourcing decision under certainty and uncertainty. When the production activity can be fragmented into two or more processes, an integrated firm must be competitive in each of the fragmented processes. There are gains from outsourcing when factor prices differ between countries. When factor prices are not equalized internationally, a firm may outsource the process that uses its scarce source intensively. If the cost of outsourcing is lower in the foreign country, full outsourcing occurs under certainty. However, even if the outside supplier has a cost advantage, uncertainty in outsourcing cost ensures that partial outsourcing is optimal for a risk-averse firm.

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To Outsource or Not to Outsource in an Integrated World

I. Introduction

There is considerable evidence that many industrial production processes are being fragmented and some parts are being imported from other countries. Research & Development activities may occur in one country, but production may be outsourced to a country with lower manufacturing costs. For instance, an electronic dictionary may be designed by a Japanese firm and for the Japanese market, but the product may be produced in China where the labor cost is low. While business firms frequently rely on outsourcing to save costs, the theory of outsourcing is just beginning to receive some attention in the literature. Recently, Chao and Yu (1993) considered fragmentation of an industry into two stages. In one industry, an intermediate good is produced using primary goods and a final good is produced in the second stage. They analyzed the welfare effects of domestic content protection which limits outsourcing of the intermediate good. Their analysis suggests that domestic content requirement has an adverse welfare effect if the non-fragmented sector is more capital intensive than the outsourced intermediate goods sector.

The purpose of this paper is to investigate the outsourcing decision of a competitive firm and delineate conditions for partial and full outsourcing under conditions of certainty and uncertainty. When a production activity is decomposed into two processes, an integrated firm must be competitive in each of the fragmented processes. Outsourcing does not occur unless a foreign supplier has a cost advantage. When a firm has a cost disadvantage in any process, full outsourcing of that process occurs under certainty. However, it is shown that when firms are risk-averse, uncertainty in outsourcing cost discourages full outsourcing and dampens international specialization of processes.
This paper is organized as follows: Section 2 considers outsourcing decision when the production activity is fragmentable into two processes. Section 3 shows that when the outsourcing cost is known, full outsourcing or no outsourcing is optimal and that partial outsourcing does not occur. Section 4 considers the outsourcing decision when the outsourcing cost is uncertain. Partial outsourcing occurs because of the risk associated with outsourcing.

2. Outsourcing versus Integrated Production

Depending on the nature of the product, the production activity of an industry may be decomposed into many processes. For instance, Airbus produces aircraft by combining cockpits produced in France, wings in the United Kingdom, tail sections in Spain, and fuselage in Germany but still imports U.S. designed engines from General Electric or Pratt and Whittney. For simplicity, we consider a competitive industry in which the output is produced by combining two processes, 1 and 2. For example, automobile production can be fragmented into two stages. The engine block is produced in the first stage and the rest of the body in the second stage.

To survive as an integrated producer, the firm must be competitive in each of the fragmentable processes. If not, the firm may be forced to outsource the uncompetitive process to a competitive external supplier. International trade in processes may explain the origin of intra-industry trade.

When will a process be outsourced to a domestic or foreign supplier? If there is a large capital requirement, the set-up cost is prohibitive, or the learning cost is exorbitant, a process may be outsourced to a domestic supplier that has a cost advantage. However, we assume that production technologies are a public good and identical between countries. Thus,
we focus on outsourcing to a foreign supplier that has a cost advantage due to international disparity in factor prices.\(^2\)

If production technologies are identical and factor prices also are equalized between countries, there are no gains from outsourcing. *Gains from outsourcing* can exist only if factor prices or production technologies are different. In this case, one process may be less costly abroad and the other more costly. Thus, we assume that factor prices are different between countries. Specifically, assume that \( w > w^* \) and \( r < r^* \), where \( w \) and \( r \) are the home wage and rent, respectively, and the asterisk (*) indicates foreign variables.\(^3\)

Assume that there are two countries and in each country a firm sells a single output under price certainty. The unit isoquants of two processes, \( y_1 = 1 \) and \( y_2 = 1 \), are shown in Figure 1. Process \( i \) uses \( a_{l_i} \) units of labor and \( a_{k_i} \) units of capital, \( i = 1,2 \), and the integrated process uses \( a_{L3} = a_{L1} + a_{L2} \) units of labor and \( a_{K3} = a_{K1} + a_{K2} \) units of capital.

It is important to note that the capital-labor ratio of an integrated process is a weighted average of the capital-labor ratios of the two fragmented processes. Which of the two processes is likely to be outsourced? In this case, there are three possibilities. First, the factor price differential may not be large enough to cause a fragmentation of the production activity and the integrated firm survives. Second, the integrated firm collapses and neither process is retained by the home firm. Third, the home firm fragments the production processes and outsources one process but retains the other. Which of the two processes will then be outsourced? Since \( w > w^* \), the home firm’s labor intensive process costs less abroad and is more likely to be outsourced to a foreign supplier.
The zero profit condition for the integrated production holds if, and only if, it holds for each production process. The relationship between price and unit costs of the two processes and the integrated output are shown by:

\[ p_1 = a_{L1}w + a_{K1}r, \]
\[ p_2 = a_{L2}w + a_{K2}r, \]
\[ p_3 = (a_{L1} + a_{L2})w + (a_{K1} + a_{K2})r. \]
If transportation costs are zero, factor price disparity implies that outsourcing the costly process is profitable. When fragmentation occurs, one process is necessarily more capital intensive and the other less capital intensive than the integrated process. Thus, the labor intensive process in a higher wage country can be outsourced to a low-wage country. Without outsourcing, the labor intensive process will be a burden to the integrated firm because it cannot compete with a team of two firms, each specializing in the process which intensively uses its cheaper factor in each country.

Since the second process uses labor intensively, it may cost less in the low-wage country, and hence it may be outsourced. In the absence of transportation costs, if a foreign
supplier has a lower unit cost \( p^*_2 = a_{t2}w^* + a_{k2}r^* \) for the second process, the associated unit value isoquant shifts to \( y_2 = 1/p^*_2 \). The level of the corresponding foreign isocost curve tangent to it at point \( C' \) will be unity, because the second process is competitive at the foreign factor prices. However, the cost of the input combinations at point \( C' \) or any other point on the same isoquant will be greater than unity at domestic factor prices. Thus, the integrated firm must shut down the second process. It simply cannot compete with a team of fragmented firms, one specializing in the first process in the high-wage country and the other in the second process in the low-wage country. Thus, the integrated firm will be forced to fragment the production processes and outsource the second process to the foreign country.

On the other hand, if transportation costs are positive, the integrated firm may not outsource the second process. For instance, due to transport costs, an external supplier may quote price \( p'_2 \), which is higher than the integrated firm’s unit cost \( p_2 \). Then the foreign producer cannot compete, and the integrated firm is not jeopardized. Both processes of the integrated firm are competitive, and the unit value isoquant of the integrated firm is tangent to the common isocost curve \( AC \).
3. The Certainty Model

We now formally consider a firm’s outsourcing decision under price certainty. The results will then be compared with those obtained under price uncertainty. It is shown that the outsourcing decision under certainty is a razor-sharp result because when it occurs, the firm outsources the process completely. That is, partial outsourcing does not occur. However, when the outsourcing cost is uncertain, it is possible for a firm to outsource some portion of a process and hence some in-house production is optimal.

Assume that the firm has a cost advantage in the first process due to its large capital investment, but the second process can be outsourced to a foreign supplier. For example, an automobile producer may have an assembly plant, but it may outsource the production of the
engine block or tires. Let $Z$ be the total number of automobiles produced, and let $C(Z)$ be the first stage cost of producing car bodies. In the second stage, one engine block is assembled with one body frame. The engine block may be produced in-house or outsourced. Let $X$ be the number of engine blocks produced in-house, and let $Y$ denote the number of engine blocks outsourced. Once the engine blocks are produced in-house or delivered from an external supplier, they are combined with other components to form an integrated product and there is no assembly cost.

The first stage production cost is given by $c(Z) = c(X + Y)$. If produced within, the cost of the engine block is $p_1X$, where $p_1 = a_{l_1}w + a_{k_1}r$ is the integrated firm’s unit cost of the second process. If outsourced, the firm pays $b$ per unit purchased. In the absence of uncertainty, the firm’s problem is whether to integrate the two processes and produce the whole product in-house, or to outsource the second process.

**Integrated Production**

If the two processes are integrated, the firm’s profit is:

$$\pi = p_3X - p_1X - c(X),$$

(4)

where $c(Z) = c(X)$ is the in-house production cost of the second process. The first order condition for integrated production is:

$$p_3 - p_1 - c' = 0.$$  

(5)

That is, the output of the vertically integrated firm is determined at a point where price equals marginal cost, $p_1 + c'$. 

9
Outsourcing

Next, consider production decisions when the firm outsources the second process. The firm’s problem is to choose $X$ and $Y$ to maximize

$$\pi = p_3(X + Y) - p_1 X - bY - c(X + Y).$$

There are three possible solutions. First, the firm produces nothing in-house ($X = 0$) and outsources the entire second process. Second, the firm outsources nothing ($Y = 0$) and produces the entire second stage output in-house, which amounts to no fragmentation as considered earlier. Third, in the second process the firm may produce some products in-house and outsource the rest elsewhere ($X > 0, Y > 0$). To conduct some of the second process activity in-house, the first order condition is:

$$p_3 - p_1 - c' = 0,$$  \hspace{1cm} (6)

which is the same condition as that for integrated production examined earlier.

On the other hand, the first order condition for the firm to outsource some of the second process activity ($Y > 0$) is:

$$p_3 - b - c' = 0.$$

(7)

It follows that:

$$Y = 0, \text{ if } p_1 < b,$$

i.e., no outsourcing is optimal if the outsourcing cost is higher than the in-house production cost of the second process.
On the other hand,

\[ X = 0, \text{ if } p_i > b. \]

That is, if the outsourcing cost is less than in-house production cost, the firm has a cost disadvantage in the second process. In this case, outsourcing is not only optimal, but also the firm chooses full outsourcing of the second process. For instance, an automobile firm may completely outsource the production of tires or engines. Similarly, Airbus imports all the engines from its competitors in the United States.

Finally, if \( p_i = b \), then the firm is indifferent between outsourcing and in-house production of the second process, and hence there is no need to fragment the production activity.\(^4\) Thus, the acid test of outsourcing is whether the firm has a cost disadvantage in the second stage: The firm outsources only if the in-house unit production cost of the second process is higher than its unit outsourcing cost. Moreover, it results in full outsourcing, as in Bond (2000).

4. Fragmentation under Price Uncertainty

The certainty case shows that an integrated firm has no need to fragment the production process unless there is a clear cost disadvantage in one of the fragmented processes. We now consider the outsourcing decision when the outsourcing cost is uncertain. Outsourcing contracts are generally signed before the production quality is checked. A contract may fix a nominal price \( a \), but the unit cost of outsourced process \( b = a\theta \) may be uncertain, where \( \theta \) is a random variable with \( E\theta = 1 \). For instance, if a defect is found, the relevant part may have to be recalled and repaired, or consumers may return the product,
thereby raising the selling cost of the product. Thus, the actual unit cost $b$ of outsourcing is a random variable with expected value $Eb = a$.

The expected utility is:

$$EU\left[ p_3(X + Y) - p_1X - bY - c(X + Y) \right]. \quad (8)$$

The first order conditions for $X > 0$ and $Y > 0$ are:

$$EU'(p_3 - p_1 - c') = 0. \quad (9)$$

$$EU'(p_3 - b - c') \equiv EU' E(p_3 - b - c') + Cov(U', -b) = 0. \quad (10)$$

Since there is no uncertainty for in-house production, (9) reduces to

$$p_3 = p_1 + c'. \quad (11)$$

This means that the firm’s in-house production of the engine block is unaffected by outsourcing cost uncertainty. Differentiating $U'$ with respect to $b$ gives

$$\frac{dU'}{db} = U''(d\pi / db) = -U''Y > 0.$$ 

Thus, $Cov(U', -b) < 0$ for $Y > 0$. Thus, (10) implies that for $Y > 0$

$$p_3 > Eb + c'. \quad (12)$$

That is, a risk-averse firm outsources less under price uncertainty than if expected unit outsourcing cost is known with certainty.
Consider the special case where the expected outsource cost $Eb$ is equal to the in-house cost. Recall that this was an acid test of outsourcing under certainty. If $p_1 = Eb$, then the second term, $\text{Cov}(U', -b)$, on the left side of the equation in (10) when evaluated at $Y = 0$ reduces to zero, because $U'[p_3X - p_1X - c(X)]$ is no longer a random variable.

Moreover, the first term on the left side of the equation in (10) reduces to:

$$EU'(p_3 - b - c') = U'[p_3X - p_1X - c(X)]E(p_3 - b - c'). \quad (13)$$

Substituting $p_1 = Eb$ into (13) and using (11), we get

$$EU'(p_3 - b - c') = U'[p_3X - p_1X - c(X)](p_3 - p_1 - c') = 0, \quad (14)$$

which implies $Y = 0$ is an optimal solution. That is, if expected outsourcing cost is equal to in-house cost ($Eb = p_1$), then no outsourcing is optimal for all risk-averse firms. Thus, a necessary condition for outsourcing the second process is that the expected unit cost of outsourcing is less than in-house unit cost, $Eb < p_2$.

**Proposition 1**: Assume that a risk-averse competitive firm makes outsourcing and in-house production decisions before observing the unit outsourcing cost $b$.

(i) If the expected unit outsourcing cost $b$ is equal to in-house unit cost $p_1$, then no outsourcing is optimal, and

(ii) If $Eb < p_2$, then partial outsourcing is optimal, i.e., a risk-averse firm partially outsources and retains some of the second process in-house.
We now compare the result of Proposition 1 with the certainty case. If the in-house unit cost and outsourcing price are identical under certainty \((a = b)\), the firm is indifferent about outsourcing and in-house production. If outsourcing costs less \((b < a)\), then the firm chooses full outsourcing of the second process. However, when the expected unit outsourcing cost is less than the known in-house cost, a risk-averse firm does not choose full outsourcing and some output of the second process activity will occur in the home country.

5. Concluding Remarks

An integrated firm must be competitive in each fragmented process. Under certainty, the firm outsources a process only if an external supplier has a cost advantage. Moreover, when it occurs the fragmented firm chooses full outsourcing of the costly process.

Uncertainty in outsourcing cost tends to prevent fragmentation. Specifically, if the expected outsourcing cost is equal to the known in-house cost of a process, no outsourcing is optimal for all risk-averse firms. Moreover, a risk-averse integrated firm chooses partial outsourcing even if it has a cost disadvantage. In this way, outsourcing becomes a diversification strategy.
References


Endnotes

1 Bond (2001) used a specific factors model and delineated the conditions under which partial or full outsourcing is optimal.

2 This assumption follows the tradition of the Hescher-Ohlin model and differs from Bond (2001), in which only the domestic firm has the technology for the second stage.

3 If domestic factor prices \( w \) and \( r \) are both higher or lower than their foreign counterparts, one country exports all goods to the other country.

4 In this case, partial outsourcing is also a feasible solution in a mathematical sense. However, for an integrated firm, there is no need to fragment the processes and outsource the first stage.