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PARTIAL SUBCONTRACTING, MONITORING COST, AND MARKET STRUCTURE*  

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Abstract  

We analyze the role of subcontracting in industries where firms compete with their design of organizational production mode as strategic instrument. In particular, we investigate the decision of what fraction of components to produce internally and what fraction to subcontract. In-house production of components is assumed to generate monitoring costs, which increase as a convex function of the number of production lines managed in-house. We characterize the relationship between the equilibrium fraction of inputs subcontracted and the market structure of the final-product market. A monopoly is shown to reduce the fraction of subcontracted inputs compared with the fraction outsourced by competing brand-producing firms. Under duopoly, the outsourcing decisions are found to be strategic substitutes. Finally, we investigate the welfare implications of horizontal mergers under complete and incomplete market coverage.

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1. Introduction

All over the industrialized world subcontracting has become an increasingly popular method for firms to organize their production in order to achieve competitiveness. Many scattered observations support such a view. A large number of such examples are listed in Domberger (1999), and therefore we will mention only a few ones. Almost all producers of personal laser printers do not make the engines, but instead buy these engines from Canon, a Japanese manufacturer. Most personal computers operate on a central processing unit (CPU) produced by Intel. Whereas the Intel chips are patented (or copyrighted), PC producers have the option of licensing production processes for producing clone chips in house. Thus, the choice to buy chips from Intel can be viewed as the choice to subcontract a (key) component.

The American aircraft manufacturer Boeing subcontracts over 34,000 components from different manufacturers to be assembled into its 747 passenger aircraft. Illustrating the same phenomenon, Grossman and Helpman (1999) refer to the 1998 annual report of the World Trade Association as offering support for the view that only 37 percent of the production value of a representative ”American” car is generated in the United States. In Finland, The Confederation of Finnish Industry and Employers has estimated that subcontracting constituted up to approximately 50 percent of the sales of Finnish manufacturing firms (excluding those operating in the energy industries) in 1996. The magnitude of these subcontracting activities was estimated to have increased by 30% during the period 1993-96 and these activities were expected to exhibit a continued growth at a similar pace until the end of the century. It has also been estimated that Nokia alone makes use of more than three hundred domestic (Finnish) subcontractors in addition to an almost equally high number of foreign subcontractors. The activities outsourced range from advanced R&D to subcontracting of traditional production phases. Activities of outsourcing the design and maintenance of IT-service systems, like, for example enterprise-resource-planning (ERP), for production and management purposes offers still another current example illustrating common expectations for future proportional growth of firms’ outsourcing activities. Business analysts of the IT-service industry seem to unanimously expect an exponential growth of application
outsourcing of IT-services like those of ERP.

A long-term research approach in organization theory, originated with the famous contribution by Coase (1937), has offered important perspectives for understanding subcontracting practices by asking the following question. Why is it that such a large proportion of the economic activity is carried out within organizations like firms despite the fact that the decentralized market is known to be a very efficient mechanism for the allocation of scarce resources? For example, Williamson (1985) as well as Grossman and Hart (1986) characterize the factors determining the boundaries of firms in terms of the nature and sources of transaction costs, asset specificity and incomplete contracts in different types of economic environments. Holmström and Roberts (1998) offer an updated survey of the past decades of research about the boundaries of firms. According to them the last two decades of research about the boundaries of firms has placed particular emphasis on the importance of “hold-up” problems between transacting parties.

Even though contract theory has been instrumental for understanding some important aspects of a firm’s outsourcing decisions, the literature still offers a very fragmented and incomplete picture of the role of outsourcing in industries where firms compete with their design of organizational production mode as a strategic instrument (see Nickerson and Vanden Berg (1999) as well as Shy and Stenbacka (forthcoming)). In particular, the existing contributions seem to offer no knowledge on the strategic factors, which determine the fraction of inputs outsourced by brand producing rivals competing in the product market. The present paper aims at filling this gap by presenting a detailed analysis focusing on the following questions: What is the strategic impact of subcontracting by one firm on the outsourcing activities of a rival, if these firms are engaged in price competition in the market for final goods? Which types of inputs are more likely to be subcontracted and which types of activities are more likely to be produced in-house? In order to emphasize explicitly the strategic incentives determining the pattern of partial subcontracting we carry out this task within a framework where oligopoly firms a priori have access to a technology identical to that of subcontractors. In principle, the competing oligopolists face a tradeoff between whether to make
an irreversible investment in a production facility for supplying the component in-house or
to accept buying the component from a subcontractor adding a profit-maximizing markup
in determining the price at which the oligopolists have access to the component.

The management of in-house production requiring huge amounts of components, like
the 747 passenger aircraft mentioned above, is typically associated with substantial intra-
organizational monitoring costs. It is reasonable to assume that the monitoring costs increase
at an increasing rate as a function of the number of component product lines required for
in-house production of the final good. Consequently, as the fraction of components produced
in-house becomes sufficiently large, outsourcing will outperform internal production despite
the markup charged by the subcontractor. The present analysis formalizes this intuition.
Furthermore, we analyze how the market structure in the final goods’ market will impact on
the fraction of subcontracted inputs.

A number of important research contributions have focused on aspects of subcontracting
or outsourcing different from those we concentrate on. Kamien, Li and Samet (1989) explore
a model with Bertrand competition where two competitors are allowed to subcontract pro-
duction to each other. They apply an auction approach where the firm making the lowest
bid wins a contract and can subsequently subcontract production to the loser. In such a
context they analyze in detail how the possibility of subcontracting will alter firms’ behavior
in the bidding stage. Spiegel (1993) presents an analysis where rival firms with asymmetric
convex costs can make use of horizontal subcontracting in order to allocate production
more efficiently and he evaluates the welfare consequences of such a form of subcontracting.
With the main focus on aspects of uncertainty Van Mieghem (1999) applies a real options
approach to calculate the option value of subcontracting in a situation where a commitment
to establishing capacity for in-house production would have to be made in the presence of
a high degree of uncertainty. Finally, it should also be mentioned that international trade
theorists have been interested in international outsourcing whereby input-producing activities
are allocated from one country to another as a mechanism of exploiting differentials in
competitiveness between countries (for an early literature survey see Ruffin, 1994).
The present study is organized as follows. Section 2 develops a basic duopoly model where each firm can alter its organization of production by varying the fraction of components it decides to subcontract. In Section 3 we characterize the subgame-perfect fraction of subcontracted inputs and determine the strategic nature of the interaction with respect to the outsourcing decisions. In order to clarify the relationship between product market structure and the magnitude of the subcontracting activities, Section 4 compares the optimal outsourcing decisions on behalf of a merged (monopoly) firm in the market for final goods to those made in a duopoly industry. Finally, Section 5 offers concluding comments.

2. The Model

Consider an industry with two firms, indexed by $j = A, B$, selling differentiated brands to heterogeneous consumers. Let $p_A$ denote the price charged by firm $A$, and $p_B$ the price charge by $B$.

2.1 Consumers

There is a continuum of consumers in this market. Following Hotelling (1929), product differentiation is captured by assuming that consumers are indexed by $x$ on the unit interval with uniform density (of $n$ consumers per type). The utility of a consumer indexed by $x$, $x \in [0, 1]$, is

$$U_x \eqdef \begin{cases} 
\beta - p_A - \tau x & \text{when buying from } A \\
\beta - p_B - \tau (1 - x) & \text{when buying from } B \\
0 & \text{when not consuming any brand.}
\end{cases}$$

The parameter $\beta$ measures a consumer’s basic utility derived from the consumption of this good. Thus, a consumer indexed by a “low $x$” is oriented towards brand $A$ whereas a consumer indexed by a “high $x$” is oriented towards brand $B$. The parameter $\tau > 0$, which we refer to as the differentiation parameter, measures the transportation cost per unit of distance. As conventional in models of product differentiation, this parameter captures the disutility an individual experiences from consuming a product variety different from his ideal brand.
2.2 Production, inputs, and subcontracting

Each brand-producing firm produces its final good by making use of a continuum of inputs indexed by $i \in I \equiv [0, \phi]$, where $\phi > 0$. Each input $i$ can be produced at the firm’s plant, or alternatively it can be subcontracted to be manufactured by an independent firm which specializes in the production of this input.

As a characterization of the technology the cost of producing one unit of input $i$, $i \in I$, is $c(i)$. A subcontractor charges a price for input $i$ captured by the markup function $s(i) = M + m \cdot c(i)$, where $m, M \geq 0$. The parameter $M$ measures the flat markup whereas $m$ captures the proportional markup levied by a profit-maximizing subcontractor. For reasons of tractability, we assume this markup factor to be invariant across different inputs. Such a simplification can be justified in an environment where the subcontractors, independently of their specialization, enjoy the same degree of monopoly power. We also assume that $M + mc(i) \geq c(i)$ for all $i \in [0, \phi]$, which implies that, excluding monitoring cost considerations analyzed below, it is always more costly to outsource the production of an input than to produce it in-house. We argue that there is no loss of generality by focusing our analysis on these types of inputs because inputs which are produced less costly by a subcontractor will always be outsourced. Thus, there is no loss of generality by confining our analysis only to the inputs that are more costly to outsource than produce internally.

With no loss of generality we index the inputs on $[0, \phi]$ according to increasing cost of producing these inputs. We confine our analysis to the class of input-cost functions given by

$$c(i) = \gamma \cdot i,$$

for $i \in I = [0, \phi], \quad (2)$

where $\gamma \geq 0$ is a parameter reflecting the variation in the cost of producing different inputs. That is, an increase in $\gamma$ increases the difference in production costs among inputs, whereas $\gamma = 0$ implies that all inputs are costless to produce. Figure 1 illustrates the production cost of each input $i \in [0, \phi]$ when produced in-house and when the input is subcontracted. We need the following definition concerning the efficiency of in-house production of inputs relative to outsourcing.
Figure 1: Input production costs (subcontractors and in-house). Rising markup \((m > 1)\); declining markup \((m < 1)\).

**Definition 1**

Outsourcing is said to exhibit a **rising markup** (relative to the cost of producing the input) if \(m > 1\), a **declining markup** if \(m < 1\), and a **flat markup** if \(m = 1\).

Thus, rising markup implies that it is more costly to outsource high-cost inputs than low-cost inputs. Conversely, declining markup implies that it is more costly to outsource less-costly to produce inputs. Definition 1 implies the following proposition.

**Proposition 1**

Suppose that a profit-maximizing brand-producing firm chooses to produce some inputs in-house, while some inputs are outsourced. Let \(k \in [0, \phi]\) denote an input produced in-house, and let \(\ell \in [0, \phi]\) denote an outsourced input. Then, (a) if outsourcing exhibits a rising markup it must be that \(k > \ell\), and (b) if outsourcing exhibits a declining markup, it must be that \(k < \ell\).

**Proof.** By assumption, the total cost of obtaining these two inputs is \(T \overset{\text{def}}{=} \gamma k + M + m\gamma \ell\). If, instead, we let \(k\) be outsourced and \(\ell\) be produced in-house the total cost of producing
these two inputs becomes $T' = \gamma\ell + M + m\gamma k$.

(a) By way of contradiction suppose that $k < \ell$. Then, $T' - T = (\ell - k)\gamma(1 - m) < 0$. Hence, the firm would not minimize costs, which means a contradiction. (b) Again, by way of contradiction suppose that $k > \ell$. Then, $T' - T = (k - \ell)\gamma(m - 1) < 0$. Hence, cost minimization would be contradicted.

Proposition 1 implies the following Corollary.

**Corollary 1**

A profit-maximizing brand-producing firm will outsource the production of the least costly inputs if the markup is rising, whereas it will outsource the production of the most costly inputs if the markup is declining.

Corollary 1 postulates an empirically testable hypothesis which links the market-determined nature of the markup on outsourced inputs (treated exogenously in this paper) to the type of inputs outsourced by brand-producing firms.

2.3 Monitoring cost

Let $I^*_j \subseteq I$ denote the set of inputs which firm $j$ does not produce internally. Thus, these inputs are subcontracted from the input-producing firms. Analogously, let $I^i_j$ be the set of inputs firm $j$ produces internally. Assuming that production requires all inputs implies that $I^i_j = I \setminus I^*_j$.

The production of inputs at the firm level requires additional costs associated with the management of the production lines needed. We refer to these costs as monitoring costs. Formally, we assume the monitoring costs to be a function of the set of inputs produced internally and these costs are captured by the function $\lambda(I^i_j)$, where $\lambda$ is a measure on $I$ satisfying $\lambda(\emptyset) = 0$ (all inputs are externally subcontracted), $\lambda(I) = \infty$ (all inputs are produced by the firm). We also assume that this measure satisfies strict monotonicity so $I'' \subset I'$ implies that $\lambda(I'') < \lambda(I')$, for every $I', I'' \subseteq I$. Strict monotonicity is interpreted as the intraorganizational diseconomies of scope of monitoring resulting from internal management of a separate production line for each input produced in-house.
2.4 Cost of production and profits

We normalize our measurement of production and input units so that the production of one unit of output requires exactly one unit of each of the $\phi$ inputs (a Leontief-type production technology). Denote by $q_j$, $j = A, B$, the quantity produced by firm $j$. Then, firm $j$’s total production cost is

$$
TC_j(q_j) = \left\{ \int_{I_j^s} [M + mc(i)] \, di + \int_{I_j^f} c(i) \, di \right\} q_j + \lambda \left( I_j^f \right).
$$

The first term is the cost of production outsourced to subcontractors. The second term in (3) is the cost of producing inputs at the firm level. The third term represents the monitoring costs.

We assume each input to require a separate production line. The cost function (3) captures the idea that internal production requires the owner to invest into monitoring of each production line maintained for in-house production of components. By (3) these monitoring costs are, however, independent of the scale of production in each of these production lines. Such an assumption might be particularly relevant when supervision requires investments into understanding the production process making it possible to evaluate the performance of the production line in question independently of the actual number of input units produced in the production line. Such activities might include, for example, the development of quality control. This assumption might also be highly relevant in the presence of management complexity considerations like those considered by Fershtman and Kalai (1993).

In some instances it is easier to think of the production cost as output times marginal cost plus the monitoring costs. In this case, we define the marginal cost of producing one unit of brand $j$, $j = A, B$, by

$$
c_j \overset{\text{def}}{=} \int_{I_j^s} [M + mc(i)] \, di + \int_{I_j^f} c(i) \, di.
$$

Clearly, $TC_j(q_j) = c_j q_j + \lambda \left( I_j^f \right)$. Altogether the profit of each brand-producing firm $j$, $j = A, B$, is

$$
\pi_j(q_j) = p_j q_j - TC_j(q_j) = (p_j - c_j) q_j - \lambda \left( I_j^f \right),
$$
where $TC_j(g_j)$ is defined in (3) and $c_j$ in (4).

3. Equilibrium Choices of Subcontracting

We now approach the core of this study by posing the following questions.

(a) What determines the fraction of inputs outsourced by brand-producing firms with market power in the product market?

(b) What are the strategic effects of subcontracting on the price competition in the market for final goods? More precisely, how does the choice of subcontracting by one firm affect the choice of subcontracting by a rival firm?

(c) Which types of inputs are likely to be subcontracted and which types are more likely to be produced internally?

3.1 The sequence of decisions

We consider a two-stage game defined as follows.

Stage I: Each firm decides on the set of inputs to be produced internally ($I^f_j$), and the set of inputs to be subcontracted ($I^s_j$).

Stage II: Each firm takes the cost structures of both firms as given and chooses its price to maximize profit given the price set by the rival firm.

We look for a Subgame-Perfect Equilibrium for this two-stage game.

3.2 Second-Stage Equilibrium (given cost structures)

We initially solve for stage II of the game. In stage I of this game, each firm’s choice of which inputs to subcontract and which inputs to produce internally uniquely determines the firm’s cost structure which is given in (3) or (4). Therefore, let $c_A$ and $c_B$ be given unit costs of the brand-producing firms as defined in (4), and let $\lambda_A$ and $\lambda_B$ be the given monitoring costs.
Also, let $\hat{x}$ denote the consumer who is indifferent between buying brand $A$ and brand $B$. In view of the utility function (1), this consumer is defined by

$$-p_A - \tau \hat{x} = -p_B - \tau (1 - \hat{x}), \text{ or } \hat{x} = \frac{1}{2} + \frac{p_B - p_A}{2\tau}. \tag{6}$$

The profit of each firm (for a given chosen cost structure for its input) is now given by

$$\pi_A = p_A n\hat{x} - TCA(n\hat{x}) = (p_A - c_A) n\hat{x} - \lambda_A, \quad \text{and} \quad \pi_B = p_B n(1 - \hat{x}) - TCB[n(1 - \hat{x})] = (p_B - c_B) n(1 - \hat{x}) - \lambda_B. \tag{7}$$

Appendix A demonstrates how profit levels and quantity sold are calculated in this version of the Hotelling model. From Appendix A we find that

$$\pi_A = \frac{n(3\tau - c_A + c_B)^2}{18\tau} - \lambda_A, \quad \text{and} \quad \pi_B = \frac{n(3\tau + c_A - c_B)^2}{18\tau} - \lambda_B. \tag{8}$$

In what follows, our analysis will focus on the derivation of various equilibria. Closed-form solutions cannot be obtained for the general model. Therefore, at this point it is worthwhile to associate the monitoring cost with a specific functional form. Let $\mu$ be the Lebesgue measure on $\mathbb{R}$. Then, we define the total monitoring cost associated with in-house production of inputs by firm $j$ by

$$\lambda_j \overset{\text{def}}{=} \frac{\mu(I^j_f)}{\mu(I^j_s)}, \quad j = A, B. \tag{9}$$

Clearly, if all inputs are produced in-house ($\mu(I^j_s) \to 0$) the cost of monitoring approaches infinity. In contrast, the monitoring cost vanishes when the production of all inputs is subcontracted ($\mu(I^j_s) \to \phi$).

The model is now solvable in the sense that a unique equilibrium always exists. However, an explicit closed-form solution is not always obtainable for all classes of input cost functions. More precisely, the equilibrium with an organizational mode of partial subcontracting associated with the input cost functions displayed in Figure 1 is determined by a non-degenerate third-degree polynomial if $M > 0$. However, for the two cases of a rising markup and a flat markup, respectively, we can derive simple closed-form solutions. Therefore, Section 3.3
below solves for an equilibrium under a rising markup where \( M = 0 \) and \( m > 1 \). Section 3.4 then solves for an equilibrium under a flat markup where \( M > 0 \) and \( m = 1 \). These two sections are suggestive regarding the general properties of subcontracting and the reader who would like to compute the number of inputs subcontracted for the more general markup functions displayed in Figure 1 can easily simulate the solution on a computer using an exactly identical procedure.

### 3.3 Equilibrium under rising markup

Suppose now that \( M = 0 \) and \( m > 1 \). By Definition 1 the markup is rising. Hence, by Corollary 1 there exists \( \hat{i}_j \in [0, \phi] \) for which every input \( i \in [0, \hat{i}_j] \) is subcontracted while every input \( i \in [\hat{i}_j, \phi] \) is produced in-house. Therefore, (4) can now be expressed as

\[
c_j = \int_0^{\hat{i}_j} m\gamma i \, di + \int_{\hat{i}_j}^{\phi} \gamma i \, di = \frac{\gamma[(m - 1)(\hat{i}_j)^2 + \phi^2]}{2}. \tag{10}
\]

Substituting (10) and (9) into (8), the subcontracting decision of firm \( j \) at stage I is for a given choice of firm \( k \), \( \hat{i}_k \), to choose \( \hat{i}_j \) that solves

\[
\max_{\hat{i}_j} \pi_j = \frac{n\left\{6\tau + \gamma(m - 1)\left[(\hat{i}_k)^2 - (\hat{i}_j)^2\right]\right\}^2}{72\tau} - \frac{\phi - \hat{i}_j}{\hat{i}_j}. \tag{11}
\]

Differentiating (11) with respect to \( \hat{i}_j \) yields the following first-order condition

\[
0 = \frac{d\pi_j}{d\hat{i}_j} = \frac{\gamma^2(m - 1)^2n(\hat{i}_j)^3(\hat{i}_j - \hat{i}_k)^2 - 6\gamma(m - 1)n\tau(\hat{i}_j)^3 + 18\phi\tau}{18\tau(\hat{i}_j)^2}. \tag{12}
\]

The second-order condition for a maximum is

\[
\frac{d^2\pi_j}{d(\hat{i}_j)^2} = \frac{\gamma^2n(\hat{i}_j)^3(m - 1)^2[3(\hat{i}_j)^2 - (\hat{i}_k)^2] - 6\gamma n\tau(\hat{i}_j)^3(m - 1) - 36\phi\tau}{18\tau(\hat{i}_j)^3} < 0 \tag{13}
\]

for a sufficiently high value of the differentiation parameter, \( \tau \). Applying the implicit function theorem on (12), the slope of the best-response parameter is found to be

\[
\frac{d\hat{i}_j}{d\hat{i}_k} = \frac{2\gamma^2m^2n(\hat{i}_j)^4(\hat{i}_k)}{\gamma^2m^2n(\hat{i}_j)^3[3(\hat{i}_j)^2 - (\hat{i}_k)^2] - 6\gamma mn\tau(\hat{i}_j)^3 - 36\phi\tau} < 0, \tag{14}
\]
where the negative inequality sign is obtained from the second-order condition (13). Thus, the best-response functions are downward sloping meaning that

**Proposition 2**

*An increase in the fraction of inputs subcontracted by one firm will reduce the fraction of inputs subcontracted by the rival firm.*

Consequently, the decisions regarding the proportion of components to be outsourced are strategic substitutes. Intuitively, these decisions are strategic substitutes, because an increase in the amount of subcontracting by a firm increases the marginal cost of production of the final good by this firm (although reducing the monitoring cost of this firm). Hence, other things equal, the market share of the rival firm increases. Proposition 2 shows that the rival firm will take advantage of its increase in market share to further increase its market share by reducing the amount of subcontracting thereby decreasing its marginal cost (at the expense of higher monitoring cost), which, in turn, will further enhance its market share.

The two first order conditions of the profit functions (12) can be solved for symmetric choices of input subcontracting $\hat{i} = \hat{i}_A = \hat{i}_B$. This equilibrium is found to be given by

$$\hat{i} = \sqrt[3]{\frac{3\phi}{\gamma(m-1)n}}. \quad (15)$$

**Proposition 3**

*Competing firms increase their outsourcing activities when (i) production requires a more extensive set of inputs ($\phi$ increases); (ii) input cost variation declines ($\gamma$ decreases); (iii) subcontractors’ markup declines ($m$ decreases); and (iv) population density declines ($n$ decreases).*

The increased use of subcontracting can be viewed in light of the perspective offered by Proposition 3. Namely, this proposition identifies a set of variables explaining to what
extent subcontracting is employed as a production mode. We can conclude that, for example, more complicated production processes in the sense of a larger number of components and more competitive subcontractor markets are factors predicting production based on a higher proportion of subcontracting.

3.4 Equilibrium under a flat markup

Suppose now that $M > 0$ and $m = 1$ so that the markup is flat. In fact, in this case the subcontractors add a fixed markup on each component regardless of the cost of production of the input. In terms of Figure 1, this markup function is a parallel shift of $M$ above the input production cost line. Clearly, in this case brand-producing firms are indifferent regarding which inputs to produce in-house and which inputs to be outsourced. However, as we show below the number of inputs to be outsourced is uniquely determined. With $\hat{i}_j$ denoting the measure of inputs subcontracted we can without loss of generality assume that inputs $i \in [0, \hat{i}_j]$ are subcontracted, while components $i \in [\hat{i}_j, \phi]$ are produced in-house. Hence, (4) can now be expressed as

$$c_j = \int_0^{\hat{i}_j} [M + \gamma i] \, di + \int_{\hat{i}_j}^{\phi} \gamma i \, di = M\hat{i}_j + \frac{\gamma \phi^2}{2}. \quad (16)$$

Substituting (16) and (9) into (8), the subcontracting decision of firm $j$ at stage I is for a given choice of firm $k, \hat{i}_k$, to choose $\hat{i}_j$ that solves

$$\max_{\hat{i}_j} \pi_j = \frac{n \left\{ 3\tau + M(\hat{i}_k - \hat{i}_j) \right\}^2}{18\tau} - \frac{\phi - \hat{i}_j}{\hat{i}_j}. \quad (17)$$

Note the parameter $\gamma$ has cancelled out as the firms are indifferent regarding which inputs to subcontract and which inputs to produce in-house. Differentiating (17) with respect to $\hat{i}_j$ yields the following first-order condition

$$0 = \frac{d\pi_j}{d\hat{i}_j} = \frac{M^2 n(\hat{i}_j)^2(\hat{i}_j - \hat{i}_k) - 3M\tau(\hat{i}_j)^2 + 9\phi\tau}{9\tau(\hat{i}_j)^2}. \quad (18)$$

The second-order condition for a maximum is

$$\frac{d^2\pi_j}{d(\hat{i}_j)^2} = \frac{M^2 n(\hat{i}_j)^3}{9\tau(\hat{i}_j)^3} - 18\phi\tau < 0 \quad (19)$$
for a sufficiently high value of $\tau$, the differentiation parameter. Applying the implicit function theorem on (18), the slope of the best-response functions is found to be

$$\frac{d\hat{i}_j}{d\hat{i}_k} = \frac{M^2 n(\hat{i}_j)^3}{M^2 n(\hat{i}_j)^3 - 18\phi \tau} < 0,$$

where the negative inequality sign is obtained from the second-order condition (19). Thus, the best-response functions are downward sloping. The two first order conditions of the profit functions (18) can be solved for symmetric choices of input subcontracting $\hat{i} = \hat{i}_A = \hat{i}_B$. This equilibrium is given by

$$\hat{i} = \sqrt{\frac{3\phi}{Mn}},$$

which can be easily compared to the equilibrium with a rising markup, (15). Such a comparison reveals that the proportion of outsourced production is qualitatively determined by the same factors as those in the case of a rising markup except for the fact that cost variations between different components play no role any longer. Of course, the exact functional form of the outsourcing equilibrium is slightly different.

4. The Relationship Between Market Structure and Subcontracting

In this section we compare the effects of market structure on the decision to subcontract the production of inputs. Suppose for that reason that the two brand-producing firms are owned by a single final-goods manufacturer. One can simply think of a horizontal merger between firms $A$ and $B$. Assuming that the entire market is served, (1) implies that the monopoly sells each brand for a price of $p = \beta$. Hence, such a two-brand monopoly produces $q_A = n/2$ units of brand $A$ and $q_B = n/2$ units of brand $B$. Since the revenue (equals to $\beta$) does not vary with cost, the monopoly firm chooses $\hat{i}$ to minimize its total cost.
4.1 Rising markup

In view of (3), the optimal outsourcing is determined by

\[
\min_i TC^M(n) = n \left[ \int_0^i m \gamma i \, di + \int_i^\phi \gamma i \, di \right] + \frac{\phi - \hat{i}}{i} 
\]

\[
= \frac{\gamma n(\hat{i})^3(m - 1) + \hat{i}(\gamma n\phi^2 - 2) + 2\phi}{2(\hat{i})},
\]

where superscript \( M \) stands for monopoly. The first- and second-order conditions for cost minimization are

\[
0 = \frac{dTC^M}{d\hat{i}} = \frac{\gamma n(\hat{i})^3(m - 1) - \phi}{(i)^2} \quad \text{and} \quad \frac{d^2TC^M}{d(i)^2} = \frac{\gamma n(\hat{i})^3(m - 1) + 2\phi}{(i)^3} > 0
\]

yielding a unique optimum given by

\[
\hat{i}^M = \sqrt[3]{\phi} \gamma n(m - 1).
\]

4.2 Flat markup

With a flat markup the optimal outsourcing is determined by

\[
\min_i TC^M(n) = n \left[ \int_0^\hat{i} (M + \gamma i) \, di + \int_i^\phi \gamma i \, di \right] + \frac{\phi - \hat{i}}{i} 
\]

\[
= \frac{2Mn(\hat{i})^2 + \hat{i}(\gamma n\phi^2 - 2) + 2\phi}{2(\hat{i})}.
\]

The first- and second-order conditions for cost minimization are

\[
0 = \frac{dTC^M}{d\hat{i}} = \frac{Mn(\hat{i})^2 - \phi}{(i)^2} \quad \text{and} \quad \frac{d^2TC^M}{d(i)^2} = \frac{2\phi}{(i)^3} > 0
\]

yielding a unique optimum given by

\[
\hat{i}^M = \sqrt{\frac{\phi}{Mn}}.
\]
4.3 A comparison

Comparing (15) with (23) and (21) with (25) reveals that \( \hat{i}^M < \hat{i} \). Hence, we conclude with the following proposition.

**Proposition 4**

A monopoly supplying both brands will reduce the fraction of subcontracted inputs compared with the fraction of inputs subcontracted by competing brand-producing firms.

The intuition behind Proposition 4 is as follows. Monitoring costs increase with the number of production lines (number of inputs) produced in-house. The scale of production was assumed, however, not to affect the monitoring costs. Thus, with a higher scale of production, a monopoly firm can reduce its costs by producing more in-house. Table 1 summarizes the two effects determining the incentives to increase subcontracting under the two market structures.

<table>
<thead>
<tr>
<th>Market Structure</th>
<th>Strategic Effect</th>
<th>Monitoring Cost/Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duopoly</td>
<td>–</td>
<td>+ (large)</td>
</tr>
<tr>
<td>Monopoly</td>
<td>none</td>
<td>+ (small)</td>
</tr>
</tbody>
</table>

**Table 1:** Effects leading to increased subcontracting

Table 1 highlights the fact that the monitoring cost per output effect dominates the strategic effect which generates less subcontracting. The result, of course, depends on the particular class of monitoring cost functions given in (9). However, this type of monitoring cost function is needed to generate strict partial subcontracting which is widely observed in most industries.

As long as all the consumers are served we can conclude that the market structure in the brand-producing industry has an unambiguous impact on the fraction of inputs subcontracted. Within the context of our model the introduction of duopoly competition will increase the fraction of subcontracted inputs by a constant factor, \( \sqrt[3]{3} \) for the rising markup case, and the factor \( \sqrt{3} \) for the flat markup case. This means that brand-producing firms
would be able to increase their profits by coordinating their decisions with respect to the production mode so as to reduce the fraction produced based on subcontracting.

5. Conclusion

In the present study we have investigated the issue of whether to produce internally or subcontract when it comes to production processes requiring a large amount of inputs. In-house production has been assumed to generate monitoring costs, which increase as a convex function of the number of production lines managed in-house. In such a setting we have characterized the relationship between the fraction of inputs subcontracted and the market structure of the product market. A product monopoly was shown to reduce the fraction of subcontracted inputs compared with the fraction outsourced by competing brand-producing firms. Further, the decisions regarding the fraction of inputs to outsource were found to be strategic substitutes.

The present model has underestimated the incentives for subcontracting in several respects. Instead of gains from specialization in the production of inputs, our model has focused on diseconomies of scope associated with management of production lines. In terms of cost considerations the nature of the intra-organizational monitoring costs provides the incentive for partial subcontracting despite the markup charged on the outsourced components. Also, we have abstracted from the option value of subcontracting as a mechanism for transmitting risks to subcontractors.

Appendix A. Equilibrium Prices and Profit Levels in the Hotelling model with Different Unit Costs

We derive equilibrium prices assuming that the two firms may have different unit production costs, $c_A$ and $c_B$. Since monitoring costs are already predetermined by the decisions made in stage I, $\lambda_A$ and $\lambda_B$ do not affect pricing (as long as both firms produce), we ignore fixed costs which we later introduce directly into (8).
Substituting (6) into (5) yields that firm A takes $p_B$ as given and chooses $p_A$ that solves
\[
\max_{p_A} \pi_A = (p_A - c_A)n x = (p_A - c_A)n \left[ \frac{p_B - p_A}{2\tau} + \frac{1}{2} \right].
\]
The above maximization yields firm A’s best-response function
\[
p_A = \frac{\tau + c_A}{2} + \frac{p_B}{2}.
\]
Similarly, firm B takes $p_A$ as given and chooses $p_B$ that solves
\[
\max_{p_B} \pi_B = (p_B - c_B)n(1 - x) = (p_B - c_B)n \left[ \frac{p_A - p_B}{2\tau} + \frac{1}{2} \right].
\]
The above maximization yields firm A’s best-response function
\[
p_B = \frac{\tau + c_B}{2} + \frac{p_A}{2}.
\]
Solving the two best-response functions for $p_A$ and $p_B$ yield
\[
p_A = \frac{2c_A + c_B + 3\tau}{3}, \quad \text{and} \quad p_B = \frac{c_A + 2c_B + 3\tau}{3}.
\] (26)
Substituting into (6) yields
\[
\hat{x} = \frac{1}{2} + \frac{c_B - c_A}{6\tau}.
\] (27)
Substituting into the profit functions yield the equilibrium profit level
\[
\pi_A = \frac{n(3\tau - c_A + c_B)^2}{18\tau}, \quad \text{and} \quad \pi_B = \frac{n(3\tau + c_A - c_B)^2}{18\tau}.
\] (28)
References


1. Anthony Dukes & Esther Gal-Or: Negotiations and Exclusivity Contracts for Advertising

2. Oz Shy & Rune Stenbacka: Partial Subcontracting, Monitoring Cost, and Market Structure