Input Specificity and Global Sourcing

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Abstract

This paper investigates the role of productivity on a firm's organizational choice. We set up an industry-equilibrium model in which heterogeneous firms concurrently choose their type of inputs, ownership structure and location of production. In choosing their type of inputs, firms trade off the extra customization costs of adopting generic inputs against the reduced hold-up friction that generic outsourcing entails. We demonstrate that the hold-up friction under generic outsourcing increases with a firm's productivity. In our model, this implies that: (i) high productivity firms choose vertical integration to the South, (ii) medium-high productivity firms choose ideal outsourcing to the South, (iii) medium-low productivity firms choose generic outsourcing to the South, and low productivity firms choose generic outsourcing to the North.

JEL Codes: F23, F12.

Key words: input specificity, outsourcing, firm heterogeneity, incomplete contracts, hold-up problem.

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1 Introduction

In the international trade literature, firm heterogeneity is the 'new kid on the block'. As more detailed firm-level data have become available, empirical studies have unveiled a systematic relationship between productivity and a firm's organizational form. Girma, Kneller and Pisu (2005), for example, find that the productivity of UK firms engaged in FDI stochastically dominates the productivity of firms that do not. Similarly, Head and Ries (2003) find that Japanese firms engaged in FDI are more productive than those that are not. Finally, in a recent study of Japanese manufacturing firms, Tomiura (2005a) finds that only the most productive firms outsource internationally, while less productive firms outsource domestically. In a follow-up study, Tomiura (2005b) found that high productivity firms choose FDI, medium productivity firms choose international outsourcing and low productivity firms choose domestic outsourcing.

To explain the relation between productivity and a firm's organizational form, recent theoretical studies have incorporated firm heterogeneity into international trade models.[1] Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2005) map the property rights theory of Grossman and Hart (1986) and Hart and Moore (1990) into a general-equilibrium trade model with heterogeneous firms. They find that *if fixed costs differ between organizational forms*, firms will sort into different organizational forms according to their productivity level. In component-intensive industries, only the most productive firms outsource internationally because there is an extra fixed cost of sourcing internationally. In headquarter-intensive industries, they also predict that more productive firms systematically sort into organizational forms with higher fixed costs.

Using fixed cost differences to explain the sorting pattern of firms according to their productivity level may be problematic for two reasons. First, it is theoretically unclear how fixed costs are ranked across organizational forms. Antràs and Helpman (2004), for example, assume that the fixed cost of vertical integration is larger than outsourcing, while Grossman, Helpman ad Szeidl (2005) assume that the fixed cost of outsourcing is larger than vertical integration. Second, it is not clear that there is an extra fixed cost associated with internationalizing. Das, Roberts and Tybout (2001), for example, found no evidence that exporting firms need to incur some fixed

[1] This builds on a recent trade literature has analyzed the organization of international production by incorporating elements of incomplete contracts theory into general-equilibrium trade models. See Helpman (2005) and Spencer (2005) for comprehensive reviews of this literature.

cost each period to maintain a presence in foreign markets.

This paper provides an alternative explanation for the relationship between productivity and a firm's organizational form that is not solely based on differences in fixed costs. For this purpose, we relax the assumption adopted by Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2005) that inputs are completely specific, i.e. useless outside the existing relation. This is warranted since the literature on global value chain governance has consistently found that lead firms form different types of relations with their suppliers depending on the degree of specificity in the relationship. Gereffi, Humphrey and Sturgeon (2005), for example, has ranked five types of value chain relations in increasing order of specificity (see Figure 1). When there is no specificity (i.e., there is virtually no cost of switching to new parties), suppliers and lead firms interact through the *market*. In *modular value chains*, suppliers keep specificity low by using flexible manufacturing systems to produce customized components. In *relational value chains* and *captive value chains*, suppliers make specific components using specialized machinery dedicated to their customers' needs. Finally, in *hierarchies*, a vertically integrated firm controls and manages its supplier. According to Gereffi, Humphrey and Sturgeon (2005), the degree of power asymmetry between the final good firm and its supplier affects the degree of specificity adopted in the relation: when the lead firm has a relatively low power in the relationship, then a value chain with a lower degree of input specificity is adopted; when the lead firm has a relatively high power, then a value chain with a high degree of input specificity is chosen. As we shall see below, our model will provide a similar result that more productive firms adopt more specific inputs.

To introduce different degrees of input specificity into a modelling framework, we allow final good firms to choose from multiple types of inputs to produce a final good. We base this decision-making choice on Ulrich's (1995) and Schilling's (2000) work that demonstrates that the architecture of a product is an important decision-making parameter for a firm. A product's architecture determines how components interact with one another to elicit the full potential of a final product. According to Ulrich (1995) and Schilling (2000), a firm has a substantial latitude in choosing its product architecture. On the one extreme, it can adopt a *integral product architecture* to produce a final product. In this case, components are required to be specifically adjusted to each other. On the other extreme, a firm can adopt a *modular product architecture*. In this case, components are designed to interact with one another through standardized and codified interfaces. As a result, firms can adopt "generic inputs" as long as they are compatible to the standards of the modular product architecture.[2]

In this paper, we introduce this architectural choice into a modelling framework by allowing heterogeneous firms to choose between the adoption of specific inputs (i.e. integral product architecture) and generic inputs (i.e. modular product architecture).[3] In an incomplete contracting environment, this introduces an interesting trade-off: even though specific inputs circumvent customization costs, final good firms might opt for generic inputs because it reduces the hold-up friction in the relationship by giving the intermediate good firm a positive *ex post* outside option. We demonstrate that the hold-up friction under generic outsourcing continuously rises with the final good firm's productivity level. If search costs are higher in the South than in the North, our model predicts a sorting pattern that is similar to Tomiura's (2005b) empirical results: (i) high productivity firms choose vertical integration in the South; (ii) medium-high productivity firms choose ideal outsourcing to the South, (ii) medium-low productivity firms choose generic outsourcing to the South, and (iv) low productivity firms choose generic outsourcing to the North. This sorting pattern occurs despite the fact that fixed costs are assumed to be identical for all organizational forms.

The paper is organized as follows. Section 2 sets up the model. Section 3 describes the firms' optimization decisions and derives the hold-up friction under each organizational form. Section 4 then describes the equilibrium sorting of firms into different production structures and locations of production. Section 5 provides concluding remarks.

2 Model

Consider a world with two countries — the North and the South — and a single industry that produces differentiated consumer goods. Global consumers spend a fraction μ of their aggregate income on the industry and have CES preferences for industry products:

$$U = \left(\int_0^n y(i)^\alpha di \right)^{\frac{1}{\alpha}}, \tag{1}$$

[2]PCs and cell phones are good examples of modular products. They are essentially a limited number of standard parts or modules (e.g., resistors, capacitors, and memory chips), which get mounted onto printed circuit boards in different combinations.

[3]Grossman and Helpman (2002), Nunn (2005) and Feenstra and Spencer (2005) and Van Assche (2006) also consider the impact of input specificity on the organization of international production. However, these models do not consider heterogeneous firms.

where $y(i)$ is the quantity demanded of final good i and $\alpha \in [0,1]$ is a parameter that determines the elasticity of demand. There are n final good firms that each produce one final good variety i. Consumer preferences given by equation (1) lead to the following inverse demand function faced by the producer of good $y(i)$:

$$p(i) = A^{1-\alpha} y(i)^{-(1-\alpha)},\ 0 < \alpha < 1, \tag{2}$$

where p is the price of the good and

$$A = \frac{\mu}{\int_0^n p(i)^{\frac{-\alpha}{1-\alpha}} di}$$

is the aggregate consumption index. We treat the number of firms as a continuum, implying that firms take A as given.

For the production of each final good variety, two parties are required: an intermediate good firm that produces the inputs and a final good firm that has the know-how (for example, technology, distributional or servicing network) to turn the input into a final good. We assume that only the North knows how to produce final goods, while inputs can be produced in both the North and the South. We also assume that intermediate good firms supply their inputs to at most one final good firm.

Similar to Melitz (2003), in our model, final good firms differ in productivity level. To learn his productivity, a final good firm incurs an irreversible fixed cost of entry equal to F_e units of Northern labor. Upon paying this fixed cost, he learns his productivity level $\theta(i)$, which is randomly drawn from a known cumulative distribution $G(\theta)$. After observing his productivity level, the final good firm decides whether to start producing or remain idle. To initiate production, he needs to spend an additional fixed operating cost. As discussed below, this additional fixed cost is a function of the ownership structure, but not of the location of production. The existence of a fixed operating cost entails that final good firms below a certain threshold productivity level $\underline{\theta}$ remain idle. Final good $y(i)$ is produced with the production function

$$y(i) = \theta(i) x(i), \tag{3}$$

where $x(i)$ is the number of units of inputs. One unit of input $x(i)$ can be produced in the North (N) and the South (S) with one unit of labor. We assume that Southern wages ω^S are strictly lower than Northern wages ω^N and normalize the latter to 1: $\omega^S < \omega^N = 1$.

To obtain inputs, each final good firm forms an incomplete contract with one of a perfectly elastic supply of potential intermediate good firms in the

North and the South. The hold-up friction that incomplete contracts entails depends on the ownership structure. Similar to Grossman and Helpman (2002) and Ornelas and Turner (2005), we assume that inefficiencies due to contract incompleteness can be circumvented under vertical integration.[4] Under outsourcing, however, only the allocation of residual rights and a lump-sum transfer between the two parties are *ex ante* contractible, thus inducing a hold-up friction. Since the two parties *ex ante* cannot sign an enforceable contract for the purchase of a specific quantity of inputs at a specific price, they bargain over the surplus from the relationship *ex post*, i.e. after the inputs have been produced. We model this *ex post* bargaining as a Generalized Nash Bargaining game where intermediate good firms have a fixed bargaining share $\beta \in [0, 1]$. If a relationship breaks down during the *ex post* bargaining process, we assume that the contract becomes void and the *ex ante* transfer is returned. At that time, we assume that each party with residual rights can offer the original contract (including the original transfer) to a new partner. This will allow us to calculate the outside options.

The ownership structure also affects the fixed operating costs. Similar to most studies, we assume that the fixed organizational costs under vertical integration f_v is higher than the fixed organizational cost under outsourcing f_o. Unlike Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2005), however, we assume that, given the ownership structure, there is no fixed cost difference between dealing with a domestic or a foreign input provider. We shall see below that, despite this assumption, more productive final good firms will outsource internationally, while less productive firms will outsource domestically.

Final good firms *ex ante* make the technological choice between using ideal or generic inputs to produce final goods.[5] An input is ideal for final good variety $y(i)$ if it is specifically tailored to the final good and worthless otherwise. A generic input can be used by any final good variety, but requires the final good firm to spend additional customization costs ρ per unit of input to make it compatible to final good specifications. As we demonstrate below, final good firms thus face an interesting trade-off under outsourcing: on the one hand, ideal inputs circumvent customization costs. On the other hand, the adoption of generic inputs gives the intermediate good firm a positive *ex post* outside option, thus reducing the hold-up prob-

[4]Alternatively, we could follow Antràs and Helpman (2004) by assuming that *ex post* bargaining also takes place under vertical integration. As we demonstrate in Schwartz and Van Assche (2006), vertical integration in that case would never be the optimal organizational form.

[5]*Ex post*, final good firms cannot switch to a different type of input.

lem. Specifically, if the *ex ante* contract breaks down at the time of the *ex post* Nash bargaining, the intermediate good firm can form a relationship with one of the idle final good firms and obtain fraction β from the revenue generated in this new relationship. This presence of a positive *ex post* outside option increases the intermediate good firm's surplus share, thus increasing his incentive to supply inputs and reducing the hold-up problem.

To account for the stylized fact that search costs are higher across borders than within borders and that Southern firms have inferior search and communication technologies, we assume that only the Northern intermediate good firms are able to identify the threshold final good firm with productivity $\underline{\theta}$. This search cost difference implies that the intermediate good firm's *ex post* outside option differs under generic outsourcing to the North and South: while a Northern intermediate good firm in its *ex post* outside option can approach the threshold firm to form a new relation, a Southern intermediate good firm is forced to randomly sign up with any idle final good firm willing to enter in a relationship.

To summarize, active final good firms simultaneously choose three parameters *ex ante*: (i) the technological structure (i.e., whether to adopt ideal or generic inputs), (ii) the ownership structure (vertical integration or outsourcing), and (iii) the location of input production (North or South). We define *production structure* to comprise both a firm's technological and ownership structure. In particular, final good firms can choose from three feasible production structures: vertical integration (I), ideal outsourcing (O) and generic outsourcing (G).[6] We define *organizational form* (k, l) to comprise a final good firm's production structure $k \in K = \{I, O, G\}$ and location of input production $l \in L = \{N, S\}$.

The model can be summarized by the following sequences of moves: (1) the final good firm decides whether it enters the market. If he enters, he incurs a fixed cost F_e to have his productivity level $\theta(i)$ realized; (2) the final good firm decides if he wants to produce output or remain idle. If he decides to produce output, he chooses his organizational form (k, l) by simultaneously choosing the production structure $k \in K = \{I, O, G\}$ and location of input production $l \in L = \{N, S\}$. In that case, the final good firm signs a contract with an intermediate good firm; (3) the intermediate good firm produces its inputs; (4a) under vertical integration, the final goods are produced and sold; (4b) under outsourcing, there will be generalized Nash

[6]Vertical integration with the adoption of generic inputs is never feasible: the hold-up problem is the same as under vertical integration with ideal inputs, but extra customization costs are required.

bargaining between the intermediate good firm and the final good firm. The final goods are then produced and sold, after which the proceeds are divided between the parties according to the outcome of generalized Nash bargaining.

2.1 Vertical Integration

Consider first the case of vertical integration. To simplify notation, we from now on will drop the i's. Similar to Hart and Tirole (1990) and Ornelas and Turner (2005), vertical integration I solves the hold-up problem at a higher fixed cost. From equations (2) and (3), the final good firm faces the following profit function:

$$\max_x \Pi_I^l = A^{1-\alpha}(\theta x)^\alpha - w^l x - f_I, \tag{4}$$

where Π_I is the vertically integrated firm's profits, l is the location of input production and f_I is the fixed operating cost under vertical integration. By choosing the profit-maximizing amount of inputs x^*, his profit function reduces to:

$$\Pi_I^l = A\theta^{\frac{\alpha}{1-\alpha}}(1-\alpha)\left(\frac{\alpha}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}} - f_I. \tag{5}$$

Note that vertical integration in the North (I, N) will always be dominated by vertical integration in the South. Since $w^S \leq 1$, $\Pi_I^S \geq \Pi_I^N$ for any productivity level θ. Below, we will therefore only consider vertical integration to the South.

2.2 Outsourcing

Under outsourcing, a final good firm forms an incomplete contract with one of a perfectly elastic supply of potential intermediate good providers. Since the two parties cannot sign an enforceable contract for the purchase of a specific quantity of inputs at a specific price, they bargain over the surplus from the relationship *ex post*. We model this as a generalized Nash bargaining game. Under generalized Nash bargaining, each party receives the sum of its outside option plus its bargaining share of the quasi-rents. By quasi-rents we mean the surplus created in the relationship net of both parties' outside options. Let V and v denote the final good firm's and the intermediate good firm's outside options respectively; and R the total revenue (or surplus) that the two parties can make from the sale of the final good. The final good firm thus obtains

$$V_k^l + (1-\beta)\left(R_k^l - v_k^l - V_k^l\right),$$

where v_k^l, V_k^l, and R_k^l are functions of x_k^l:

$$v_k^l = v_k^l(x_k^l), V_k^l = V_k^l(x_k^l), \text{ and } R_k^l = R_k^l(x_k^l).$$

The intermediate good firm obtains

$$v_k^l + \beta\left(R_k^l - v_k^l - V_k^l\right).$$

Prior to generalized Nash bargaining, the final good firm proposes the intermediate good firm a minimum lump-sum transfer t that will guarantee the intermediate good firm's participation in the relationship. Since the supply of intermediate good firms is perfectly elastic, an intermediate good firm's participation constraint is nonnegative profits. The final good firm thus maximizes its profit function Π_k^l:

$$\max_t \Pi_k^l = V_k^l + (1-\beta)\left(R_k^l - v_k^l - V_k^l\right) - \rho_k x_k^l - f_o - t \tag{6}$$

subject to the intermediate good firm's participation constraint of nonnegative profits π_k^l:

$$\pi_k^l = v_k^l + \beta\left(R_k^l - v_k^l - V_k^l\right) - \omega^l x_k^l + t \geq 0, \tag{7}$$

where ρ is the amount of resources that a final good firm spends to customize its inputs. It is strictly positive under generic outsourcing and zero for the other production structures:

$$\rho_G > 0 \text{ and } \rho_O = \rho_I = 0.$$

By solving for the optimal lump-sum transfer t^* and taking into account the intermediate good firm's profit-maximizing output level, the final good firm's optimal form of outsourcing (k^*, l^*) solves the following:

$$\max_{k\in\{O,G\}, l\in L} \Pi_k^l = R(x_k^{l*}) - (\omega^l + \rho_k)x_k^{l*} - f_o, \tag{8}$$

subject to:

$$x_k^{l*} = \text{argmax}_x \left\{v_k^l + \beta\left(R_k^l - v_k^l - V_k^l\right) - \omega^l x_k^l\right\}. \tag{9}$$

To solve for the optimal form of outsourcing, it is necessary to determine the intermediate good firm's and final good firm's outside options v_k^l and V_k^l under each organizational form (k, l). We define a party's *ex post* outside option as the deviation payoff when a relationship breaks down, taking as given the continuance of all other relationships. Next, we summarize both parties' outside options under each organizational form.

I. Ideal Outsourcing to the North or South. Under ideal outsourcing to the North (O, N) and South (O, S), the intermediate good firm nor the final good firm has an outside option since inputs are completely specialized and worthless otherwise. This implies that for the organizational forms (O, l) we have:

$$v_O^l = V_O^l = 0. \tag{10}$$

II. Generic Outsourcing to the North. Under generic outsourcing to the North $(G,\, N)$, generic inputs can be used by all final good firms that have chosen to adopt generic inputs. In that case, the final good firm in Nash equilibrium does not have an outside option since all other intermediate good firms that have entered the market are already tied up in a relation with other final good firms. Thus, $V_G^N = 0$. The intermediate good firm, however, can offer the generic inputs x that it has produced for the original relationship to the idle threshold final good firm with productivity level $\underline{\theta}$ for a share β of total revenue $\underline{R}$ generated in this new relationship.[7] As is shown in Appendix A, the intermediate good firm's Nash equilibrium outside option under (G, N) is a constant fraction of the revenue that could have been generated in the original relation:

$$v_G^N = \beta \left(\frac{\theta}{\underline{\theta}}\right)^{-\alpha} R_G^N, \tag{11}$$

where the fraction is increasing in the intermediate good firm's bargaining share β, and decreasing in the final good firm's productivity level relative to the threshold firm $\theta/\underline{\theta}$ and the elasticity of substitution. Thus, for the organizational form (G, N), we have:

$$V_G^N = 0 \text{ and } v_G^N = \beta \left(\frac{\theta}{\underline{\theta}}\right)^{-\alpha} R_G^N. \tag{12}$$

III. Generic Outsourcing to the South. Similar to generic outsourcing to the North, the final good firm under generic outsourcing to the South $(G,\, S)$ in Nash equilibrium does not have an outside option: $V_G^N = 0$. An intermediate good firm, however, can randomly sign up with any idle final

[7] The assumption that the intermediate good firm receives share β of total revenue in the outside relationship is equivalent to assuming that he can only deviate once.

good firm willing to enter in a relationship in the event of a breakdown of the original relationship. Let θ_0 denote the lowest productivity level of such firms. Taking as given the cumulative distribution function $G(\theta)$, the Southern input provider then expects to end up with an idle final good firm with the following productivity level:

$$\xi = E\left[\theta \mid \theta \in [\theta_0, \underline{\theta}]\right] \leq \underline{\theta}.$$

The expected level of productivity ξ is lower than the threshold firm's productivity level. This leaves the Southern intermediate good firm with the following outside option:

$$v_G^S = \beta \left(\frac{\theta}{\xi}\right)^{-\alpha} R_G^S. \tag{13}$$

A comparison of (11) and (13) shows that, all else equal, the intermediate good firm's outside option under generic outsourcing to the South is lower than under generic outsourcing to the North. Thus, for the organizational form (G, S) we have:

$$V_G^S = 0 \text{ and } v_G^S = \beta \left(\frac{\theta}{\xi}\right)^{-\alpha} R_G^S. \tag{14}$$

We can now insert equations (10), (12) and (14) into equation (9) to rewrite the final good firm's optimization problem under outsourcing as:

$$\max_{k \in \{O,G\}, l \in L} \Pi_k^l = R(x_k^{l*}) - (\omega^l + \rho_k) x_k^{l*} - f_o, \tag{15}$$

subject to

$$x_k^{l*} = \text{argmax}_x \{s_k^l R_k^l - \omega^l x_k^l\}, \tag{16}$$

where the intermediate good firm's *ex post* surplus share

$$s_k^l = \begin{cases} \beta & \text{if} \quad (O, l) \\ \beta \left(1 + (1-\beta)\left(\frac{\theta}{\xi}\right)^{-\alpha}\right) & \text{if} \quad (G, S) \\ \beta \left(1 + (1-\beta)\left(\frac{\theta}{\underline{\theta}}\right)^{-\alpha}\right) & \text{if} \quad (G, N) \end{cases} \tag{17}$$

Figure 2 uses equation (17) to depict the intermediate good firm's *ex post* surplus share for the various forms of outsourcing.

[Figure 2 about here]

As is demonstrated in Figure 2, the intermediate good firm's *ex post* surplus share is a function of both the outsourcing form and the final good firm's productivity level. First, the intermediate good firm's *ex post* surplus share is higher under generic outsourcing to the North than under generic outsourcing to the South and ideal outsourcing, in that order. Second, the intermediate good firm's *ex post* surplus share under generic outsourcing to the North and South is a negative and convex function of its partner's productivity level. As its partner's productivity level increases, its *ex post* surplus share approaches that of under ideal outsourcing β. Indeed, the intermediate good firm's *ex post* surplus share gap between generic outsourcing to the North, generic outsourcing to the South and ideal outsourcing in the limit of θ approaching infinity becomes negligible.

The severity of the hold-up friction for each firm under each outsourcing form can be determined by comparing with a complete contracting environment. If contracts are incomplete, the two parties would bargain over the division of the revenue upon signing the contract and there would be no renegotiation *ex post*. It is straightforward to show that the final good firm under complete contracts chooses to adopt ideal inputs and agrees to give the intermediate good firm the entire revenue created by the relationship ($s^* = 1$).[8] In our model, we can thus capture the hold-up friction with $1 - s_k^l$. In Figure 3, we use equation (17) to depict the hold-up friction under the three forms of outsourcing.

[Figure 3 about here]

This permits us to formulate the following proposition:

Proposition 1 *For a given productivity θ, the hold-up friction increases as we go from generic outsourcing to the North, to generic outsourcing to the South and to ideal outsourcing, in that order. Under generic outsourcing to the North and South, the hold-up friction is a positive and concave function of the final good firm's productivity θ. In the limit of $\theta \longrightarrow \infty$, the hold-up friction under generic outsourcing to the North and South becomes equal to that under ideal outsourcing.*

[8]This outcome provides a nonnegative profit to the final good firm since he extracts the entire profit of the relationship via the lump-sum transfer t.

Proof. Follows from combining the definition of hold-up friction as $1 - s_k^l$, equations (18) and (17). ■

Proposition 1 has an important implication for a firm's choice of its type of inputs under outsourcing. When choosing its type of inputs, firms trade off the lower hold-up friction related to the adoption of generic inputs against the circumvention of customization costs when ideal inputs are adopted. Since the hold-up friction under generic outsourcing increases with the final good firm's productivity level, this implies that, all else equal, more productive firms will adopt ideal inputs, while less productive firms will adopt generic inputs. We will state this observation more formally in Corollary 2.

2.3 Degree of Input Specificity

To understand the impact of productivity on the hold-up friction, we can calculate the degree of input specificity for each of the three forms of outsourcing. Nunn (2005) defines an input to be specific if its value within a buyer-seller relationship is significantly higher than outside the relationship. Thus, we define *the degree of input specificity* d_k^l as the difference between the total revenue that can be created with an input within a buyer-seller relationship and the total revenue that can be created with that input in the outside option as a share of total revenue within the buyer-seller relationship.[9] In our notation:

$$d_k^l = \frac{(R_k^l - v_k^l/\beta)}{R_k^l}.$$

If $d_k^l = 0$, then there is no input specificity since the inputs are equally valuable within and outside the buyer-seller relationship. If $d_k^l = 1$, then there is complete input specificity since inputs are worthless in the outside relationship. Using the outside options v_k^l, we can calculate the degree of input specificity for each organizational form:

$$d_k^l = \begin{cases} 1 & \text{if} \quad (O, l) \\ 1 - \left(\frac{\theta}{\xi}\right)^{-\alpha} & \text{if} \quad (G, S) \\ 1 - \left(\frac{\theta}{\underline{\theta}}\right)^{-\alpha} & \text{if} \quad (G, N) \end{cases} \tag{18}$$

Figure 4 depicts the degree of input specificity and final good productivity for the three forms of outsourcing. The variable d_k^l is measured along the vertical axis and $\theta/\underline{\theta}$ is measured along the horizontal axis.

[9] See Ruiz-Aliseda (2005) for a similar definition of degree of input specificity.

[Figure 4 about here]

We can use Figure 4 to state the following lemma:

Lemma 1 *For any productivity θ of a final good firm, we have:*

$$d_G^N \leq d_G^S < d_O^l = 1.$$

Under generic outsourcing to the North and South, the degree of input specificity d_G^l is an increasing and concave function of the final good firm's productivity θ and equals to 1 in the limit of θ equals ∞.

For a given final good firm productivity θ, inputs are completely specific under ideal outsourcing since the intermediate good firm has no outside option. The degree of input specificity under generic outsourcing to the North and South, however, is less than 1 because under these two organizational forms intermediate good firms have strictly positive outside options. Comparing equations (11) and (13), the degree of input specificity under generic outsourcing to the South is higher than under generic outsourcing to the North. This is because the expected outside option under generic outsourcing to the South is lower than the outside option under generic outsourcing to the North. Finally, from equation (18), the degree of input specificity under generic outsourcing to the North and South is an increasing and concave function of the final good firm's productivity and approaches 1 as final good productivity θ goes to infinity.

3 Optimal Organizational Form

In this section, we analyze the final good firm's optimal choice of organizational form. If we solve the intermediate good firm's optimization problem given by equation (16) and insert x_k^{l*} and the corresponding price level p_k^{l*} into equation (15), we can derive the final good firm's profit maximization problem under outsourcing. We can then combine this with the profit function under vertical integration to the South presented in equation (5) to obtain a final good firm's general optimization problem. Specifically, final good firms choose the organizational form that maximizes profits:

$$\max_{k\in K, l\in L} \Pi_k^l(\theta^{\frac{\alpha}{1-\alpha}}) = A\theta^{\frac{\alpha}{1-\alpha}} Z_k^l - f_k, \tag{19}$$

where

$$Z_k^l = \left(1 - (\omega^l + \rho_k)\frac{\alpha s_k^l}{\omega^l}\right)\left(\frac{\alpha s_k^l}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}}. \tag{20}$$

and

$$s_k^l = \begin{cases} \beta & \text{if} \quad (O,S) \\ \beta\left(1+(1-\beta)\left(\frac{\theta}{\xi}\right)^{-\alpha}\right) & \text{if} \quad (G,S) \\ \beta\left(1+(1-\beta)\left(\frac{\theta}{\underline{\theta}}\right)^{-\alpha}\right) & \text{if} \quad (G,N) \\ 1 & \text{if} \quad (I,S) \end{cases} \tag{21}$$

Notice that the profit function under vertical integration to the South is the special case where $s = 1$.

As can be seen from equations (19), (20) and (21), the choice of organizational form not only depends on the ensuing hold-up friction $1 - s_k^l$, but also on other cost differences between organizational forms.[10] Specifically, final good firms also need to take into account the differences in wages w^l between the North and the South, differences in customization costs ρ_k between the adoption of ideal and generic inputs, and differences in fixed costs f_k between outsourcing and vertical integration. In Appendix B, we derive a final good firm's profit as a function of its productivity for all feasible organizational forms. This permits us to describe how firms' sorting into different organizational forms depends on productivity θ. Let θ_1, θ_2 and θ_3 denote the productivity level for which $\Pi_G^N = \Pi_G^S$, $\Pi_G^S = \Pi_O^S$ and $\Pi_O^S = \Pi_I^S$, respectively. If $\rho \leq \omega^S\left(\frac{1-\beta}{\beta}\right)$, $\alpha \leq \frac{1}{2}$, and w^S and f_I are not too small, the following proposition holds:

Proposition 2 *Generic outsourcing to the North is optimal for final good firms with* $\theta \in [\underline{\theta}, \theta_1]$*; generic outsourcing to the South is optimal for final good firms with* $\theta \in [\theta_1, \theta_2]$ *; ideal outsourcing to the South is optimal for final good firms with* $\theta \in [\theta_2, \theta_3]$*; vertical integration in the South is optimal for final good firms with* $\theta \in [\theta_3, \infty]$*.*

Proof. See Appendix B. ■

In the proof of Proposition 2, we demonstrate that under vertical integration in the South (I,S) and ideal outsourcing to the South (I,S), the profit functions are positive and linear functions of $\theta^{\frac{\alpha}{1-\alpha}}$. Under generic outsourcing to the North (G,N) and South (G,S), however, the profit functions Π_G^l are increasing and concave functions in $\theta^{\frac{\alpha}{1-\alpha}}$ if $\rho \leq \omega^l\left(\frac{1-\beta}{\beta}\right)$ and $\alpha \leq \frac{1}{2}$. Furthermore, in the limit of $\theta \longrightarrow 0$, $\Pi_G^{N\prime}$ and $\Pi_G^{S\prime}$ exceed $\Pi_O^{S\prime}$, while in the

[10] Antràs and Helpman (2004) show that the real consumption index A can be implicitly derived from the free-entry condition $\int_{\underline{\theta}}^{\infty} \Pi(\theta, A)dG(\theta) = F_e$. Then, one can use A to derive implicit solutions for the remaining values $\underline{\theta}$, θ_1, θ_2 and θ_3.

limit of $\theta \longrightarrow \infty$, $\Pi_G^{N\prime} < \Pi_G^{S\prime} < \Pi_O^S$. As depicted in Figure 5, these characteristics of the profit functions allow us to derive the sorting pattern of firms depending on their productivity level.

The intuition behind the sorting pattern is the following: low productivity firms ($\underline{\theta} \leq \theta \leq \theta_1$) choose generic outsourcing to the North (G, N) because the ensuing low hold-up friction $1 - s_G^N$ outweighs both the higher wages of producing inputs in the North and the customization costs ρ of using generic inputs. As the final good firm's productivity increases, however, the hold-up friction rises more rapidly under generic outsourcing to the North than the other organizational forms (see Figure 3). For medium-low productivity firms with $\theta_1 \leq \theta \leq \theta_2$, the benefit of lower wages in the South thus outweighs the lower hold-up friction of generic outsourcing to the North. As a result, medium-low productivity firms opt for generic outsourcing to the South (G, S). For medium-high productivity firms with $\theta_2 \leq \theta_3$, the cost of paying customization costs exceeds the benefit of a lower hold-up friction that generic outsourcing to the South entails. As a result, medium-high productivity firms choose ideal outsourcing to the South (O, S). Finally high productivity firms with $\theta \geq \theta_3$ choose vertical integration to the South since the benefits of avoiding the hold-up friction exceeds the extra fixed cost of vertical integration.

Proposition 2 is consistent with Tomiura's (2005b) empirical evidence that high productivity firms choose FDI, medium productivity firms choose international outsourcing, and low productivity firms choose domestic outsourcing. Unlike Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2004), however, the fact that more productive firms outsource internationally, while less productive firms outsource domestically is not driven by the fixed organizational cost ranking of the organizational forms. Specifically, we find that firms sort into three different forms of outsourcing despite the fact that fixed costs are identical for all outsourcing forms. We thus state the following corollary:

Corollary 1 *Under outsourcing, only the most productive final good firms internationalize since the increase in hold-up friction related to internationalization is least severe for them.*

We can use Figure 3 to provide the intuition behind Corollary 1. In Figure 3, the difference in hold-up friction between generic outsourcing to the North (G, N) and generic outsourcing to the South (G, S) is smaller for high productivity firms than it is for low productivity firms. This implies that the increase in hold-up friction related to internationalization is less severe for high productivity firms than low productivity firms. As a result, high productivity firms internationalize, while low productivity firms source domestically. Corollary 1 thus identifies a new theoretical reason why only the most productive outsourcing firms internationalize.

Proposition 2 provide insights into which type of firms are most likely to adopt generic inputs:

Corollary 2 *High productivity final good firms adopt ideal inputs, while low productivity final good firms adopt generic inputs.*

We can use Figure 3 and Proposition 1 to provide the intuition behind Corollary 2. In Figure 3, the difference in hold-up friction between generic outsourcing to the South (G, S) and ideal outsourcing to the South (I, S) is smaller for high productivity firms than low productivity firms. This implies that the benefit for high productivity firms of adopting generic inputs is smaller than for low productivity firms. As a result, high productivity firms adopt ideal inputs, while low productivity firms adopt generic inputs. Note that Corollary 2 is consistent with Gereffi, Humphrey and Sturgeon's (2005) notion that the relative power asymmetry between lead firms and suppliers is an important determinant of the degree of specificity in the relationship: when the productivity of the final good firm is high, then ideal inputs are adopted. When the final good firm's productivity is low, generic inputs are adopted.

4 Conclusion

This paper has addressed the role of productivity on a firm's optimal organizational form. For this purpose, we have set up a model in which heterogeneous final good firms concurrently choose their type of inputs (ideal or generic), ownership structure (vertical integration or outsourcing) and location of production (North or South). We have found that introducing the choice between the adoption of ideal and generic inputs creates an interesting tradeoff: while the adoption of specific inputs circumvents customization costs, final good producers might opt for generic outsourcing since it yields a lower hold-up friction than under ideal outsourcing. We have demonstrated that the hold-up friction under generic outsourcing increases with the final good firm's productivity level. This implies that final good firms sort into different forms of outsourcing depending on their productivity. We show that if search frictions are larger in the South than the North and if vertical integration requires an extra fixed costs, this implies that the highest productivity firms choose vertical integration in the South, medium-high productivity firms choose ideal outsourcing to the South, medium-low productivity firms choose generic outsourcing to the South, and low productivity firms choose generic outsourcing to the North.

Our sorting pattern is consistent with Gereffi, Humphrey and Sturgeon's (2004) prediction and Tomiura's (2005b) empirical evidence that the most productive firms choose FDI, while medium productive firms outsource internationally and low productivity firms outsource domestically. However, unlike Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2005), our sorting pattern does not solely rely on the fixed cost ranking of the organizational forms. Specifically, we assume that the fixed operating cost of all forms of outsourcing is identical. Our model thus provides a new explanation why more productive firms outsource internationalize, while less productive firms outsource domestically: given that the hold-up friction under generic outsourcing is an increasing function of the final good firm's productivity level, the cost in terms of hold-up friction of shifting input production to the South is less severe for high productivity firms.

Our model also provides novel insights into the type of inputs that firms adopt. Specifically, we find that more productive firms adopt ideal inputs, while less productive firms adopt generic inputs. This is consistent with Gereffi, Humphrey and Sturgeon's (2005) observation that the specificity in a relation increases as the relative power asymmetry between a lead firm and a supplier increase. If we proxy power asymmetry by productivity, an increase in productivity indeed leads to an increase in the degree of input specificity.

Appendix A: Derivation of equation (11)

In the calculation of the intermediate good firm's *ex post* outside option under generic outsourcing to the North, we assume that the intermediate good firm carries over the original contract to the outside relation. As a result, the intermediate good firm provides the same transfer t to the threshold firm as specified in the original contract. Furthermore, we assume that none of both parties have an outside option in the outside relation. The derivation has two steps. First, we derive the intermediate good firm's surplus share. Second, we demonstrate that the threshold firm will always end up with nonnegative profits.

Step 1. Let x denote the amount of inputs that the intermediate good firm has produced for the original relationship. Then, from equation (3), the threshold firm (with productivity $\underline{\theta}$) will be able to produce:

$$\underline{y} = \underline{\theta} x. \tag{A-1}$$

From equation (2), the corresponding output price will be:

$$\underline{\mathrm{p}} = A^{1-\alpha}(\underline{\theta} x)^{-(1-\alpha)}. \tag{A-2}$$

If the threshold firm agrees to proceed, the intermediate good firm will obtain surplus share $\beta\underline{\mathrm{R}}$ from this relationship, while the threshold final good firm obtains $(1-\beta)\underline{\mathrm{R}}$.[11] Using equations (A-1) and (A-2), the intermediate good firm's outside option equals:

$$v = \beta A^{1-\alpha}(\underline{\theta} x)^{\alpha}. \tag{A-3}$$

Using equations (2) and (3), we derive the revenue that could have been created in the inside (original) relationship:

$$R = A^{1-\alpha}(\theta x)^{\alpha}. \tag{A-4}$$

The aggregate consumption index A is identical for all final good firms. By using equation (A-4) to solve for A and inserting it into (A-3), we can express v as a function of R:

$$v_G^N = \beta \left(\frac{\theta}{\underline{\theta}}\right)^{-\alpha} R_G^N. \tag{A-5}$$

[11] Both parties face zero outside options.

From equation (A-5), the intermediate good firm's *ex post* outside option is a constant fraction of the revenue that could have been generated in the original relation.

Step 2. From equation (6), the threshold final good firm will only agree to enter the market if its profits are nonnegative:

$$\underline{\pi} = (1-\beta)A^{1-\alpha}\left(\underline{\theta}x_G^N\right)^{\alpha} - \rho x_G^N - F - t \geq 0. \tag{A-6}$$

To prove that this is the case, we need to first solve for the entire model. Once we have done so, we can solve for the optimal t^* and x^* in the original relationship. Next, we can use the characteristics of the threshold firm to solve for A. By combining these calculations, we can demonstrate that the threshold firm's profits are always nonnegative.

1. The intermediate good firm carries over the contract from the original relationship. As a result, he is required to transfer to the threshold firm the same amount t that he would have transferred in the original relationship. From equation (7), it can be derived that in the original relationship:
$$-t^* = s_G^N R(x_G^N) - x_G^N - f. \tag{A-7}$$

2. From equation (16), it can be derived that the intermediate good firm produces the following amount of inputs for the original relationship:
$$x_G^{N*} = A\left(\alpha s_G^N \theta^{\alpha}\right)^{\frac{1}{1-\alpha}}. \tag{A-8}$$

3. To solve for A, we first notice from Theorem 1 that when generic outsourcing to the North is chosen by at least one final good firm, then the least productive active final good firm chooses generic outsourcing to the North. This implies that — if at least one final good firm chooses generic outsourcing to the North — the threshold firm's profit-maximizing original form is generic outsourcing to the North. Using equations (18) and (17), the threshold firm would have had a surplus share of $1-\beta(2-\beta)$ if he would have chosen to be active. Using (16), he would have had the following amount of inputs at its disposal:
$$\underline{x}^* = A\left(\alpha\beta(2-\beta)\underline{\theta}^{\alpha}\right)^{\frac{1}{1-\alpha}}. \tag{A-9}$$

   The special characteristic of the threshold firm is that he initially is indifferent between being active in the market and remaining idle. This implies that with $\underline{x}^*$ at his disposal, he would have faced zero profits. From equation (8), this implies that:

$$A^{1-\alpha}\left(\underline{\theta}\underline{x}^*\right)^{\alpha} - (1+\rho)\underline{x}^* - f - F = 0. \tag{A-10}$$

By inserting equation (A-9) into equation (A-10), we can thus derive A:

$$A = \frac{f+F}{\left(\alpha\beta(2-\beta)\underline{\theta}\right)^{\frac{\alpha}{1-\alpha}}\left(1-(1+\rho)\alpha\beta(2-\beta)\right)}. \tag{A-11}$$

We now have all the required information to calculate whether the threshold firm in the outside relationship faces nonnegative profits. By inserting equations (A-7), (A-8) and (A-11) into (A-6) and rearranging, the threshold firm has a nonnegative profit if the following condition holds:

$$\left(\frac{s_G^N\theta}{\beta(2-\beta)}\right)^{\frac{\alpha}{1-\alpha}}\left(\frac{(1-\beta)\left(\theta/\underline{\theta}\right)^{\alpha} + s_G^N - (1+\rho)\alpha s_G^N}{1-(1+\rho)\alpha\beta(2-\beta)}\right) \geq 1.$$

This is always the case since both terms within brackets are larger than 1. We can conclude that the threshold firm is always willing to take over the original contract with the intermediate good firm.

Appendix B: Proof of Proposition 2

In this appendix, we will first demonstrate that ideal outsourcing to the North (O, N) is never optimal strategies. Next, we will analyze the characteristics of the profit functions under the remaining organizational forms. This will allow us to prove Proposition 2.

Ideal outsourcing to the North (O, N) is never an optimal strategy because it is always dominated by ideal outsourcing to the South (O, S). This is because, ceteris paribus, the hold-up friction is identical between both organizational forms, while wages in the South are lower than in the North. For the remaining organizational forms (I, S), (O, S), (G, N) and (G, S), we need to analyze the characteristics of their profit functions $\Pi_k^l(\theta^{\frac{\alpha}{1-\alpha}})$.

Vertical Integration to the South. From equations (5), the final good firm's profit function Π_I^S linearly increases in $\theta^{\frac{\alpha}{1-\alpha}}$:

$$\Pi_O^{S\prime} = A\left(\frac{\alpha}{\omega^S}\right)^{\frac{\alpha}{1-\alpha}}(1-\alpha) > 0. \tag{B-1}$$

and

$$\Pi_I^{S\prime\prime} = 0.$$

Ideal Outsourcing to the South. From equations (19) and (20), the final good firm's profit function Π_O^S linearly increases in $\theta^{\frac{\alpha}{1-\alpha}}$:

$$\Pi_O^{S\prime} = A\left(\frac{\alpha\beta}{\omega^S}\right)^{\frac{\alpha}{1-\alpha}}(1-\alpha\beta) > 0. \tag{B-2}$$

and

$$\Pi_O^{S\prime\prime} = 0.$$

Generic Outsourcing to the North and South. From equations (19) and (20), we can derive the shapes of the final good firms' profit functions Π_G^N and Π_G^S:

$$\Pi_G^{l\prime} = A\left(\frac{\alpha s_G^l}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}}\left(1-\alpha\left(\frac{s_G^l-\beta}{s_G^l}+\beta\frac{\omega^l+\rho_k}{\omega^l}\right)\right), \tag{B-3}$$

and

$$\Pi_G^{l\prime\prime} = -A\left(\frac{\alpha s_G^l}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}} \frac{s_G^l - \beta}{s_G^l \theta^{\frac{\alpha}{1-\alpha}}}\left(1 - \alpha\left(\frac{s_G^l - \beta}{s_G^l} + \beta\frac{\omega^l + \rho_k}{\omega^l}\right) - \frac{\beta(1-\alpha)}{s_G^l}\right). \tag{B-4}$$

From (B-3) and (B-4), the following conditions are sufficient for the final good firms' profit functions Π_G^N and Π_G^S to be increasing and concave functions of $\theta^{\frac{\alpha}{1-\alpha}}$:

$$\rho_G \leq \omega^S\left(\frac{1-\alpha\beta}{\alpha\beta}\right), \text{ and } \alpha \leq \frac{1}{2}.$$

To ensure that each organizational form is feasible, we also need to analyze the profit functions in their limits. Under the parameter restrictions provided above, the slopes of the profit functions under (G, N) and (G, S) in the limit of $\theta \longrightarrow 0$ approaches infinity:

$$\lim_{\theta \longrightarrow 0} \Pi_G^{l\prime} = +\infty. \tag{B-5}$$

A comparison of equations (B-2), (B-1) and (B-5) demonstrates that for low productivity levels:

$$\Pi_G^{N\prime} > \Pi_O^{S\prime} > \Pi_I^{S\prime} \text{ and } \Pi_G^{S\prime} > \Pi_O^{S\prime} > \Pi_I^{S\prime}. \tag{B-6}$$

Next, we need to determine for which productivity θ, (G, N) dominates (G, S). Let θ_1 denote the productivity level where $\Pi_G^S = \Pi_G^N$. Using equations (18), (17) and (B-3), $\Pi_G^{N\prime} > \Pi_G^{S\prime}$ for $\theta < \theta_1$ as long as w^S is not too small. $\Pi_G^{N\prime} < \Pi_G^{S\prime}$ otherwise. Combining these results with (B-6) and the characteristics of the profit functions, the following ranking of profit functions holds for low productivity levels if w^S is not too small:

$$\Pi_G^N \geq \Pi_G^S \geq \Pi_O^S \geq \Pi_I^S. \tag{B-7}$$

In the limit of $\theta \longrightarrow \infty$, the slope of the profit functions under (G, N) and (G, S) is:

$$\lim_{\theta \longrightarrow \infty} \Pi_G^{l\prime} = A\left(\frac{\alpha\beta}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}}\left(1 - \alpha\beta\left(\frac{\omega^l + \rho_k}{\omega^l}\right)\right) \tag{B-8}$$

A comparison of equations (B-1), (B-2) and (B-8) allows us to rank the slopes of the profit functions as θ approaches infinity: $\Pi_G^{N\prime} < \Pi_G^{S\prime} < \Pi_O^S < \Pi_I^S$. This is because ρ is strictly positive under (G, l) and zero under (O, S). In addition, wages are lower in the South than in the North. From the characteristics of the profit functions, this implies that for a sufficiently high productivity:

$$\Pi_G^N \leq \Pi_G^S \leq \Pi_O^S \leq \Pi_I^S. \tag{B-9}$$

These characteristics of the profit functions allow us to graphically analyze the sorting pattern of firms depending on the parameter values of ω^S and f_I. As is demonstrated in Figure 5, if w^s and f_I are not too small, the following sorting pattern occurs: generic outsourcing to the North is optimal for final good firms with $\theta \in [\underline{\theta}, \theta_1]$; generic outsourcing to the South is optimal for final good firms with $\theta \in [\theta_1, \theta_2]$; ideal outsourcing to the South is optimal for final good firms with $\theta \in [\theta_2, \theta_3]$; vertical integration in the South is optimal for final good firms with $\theta \in [\theta_3, \infty]$.

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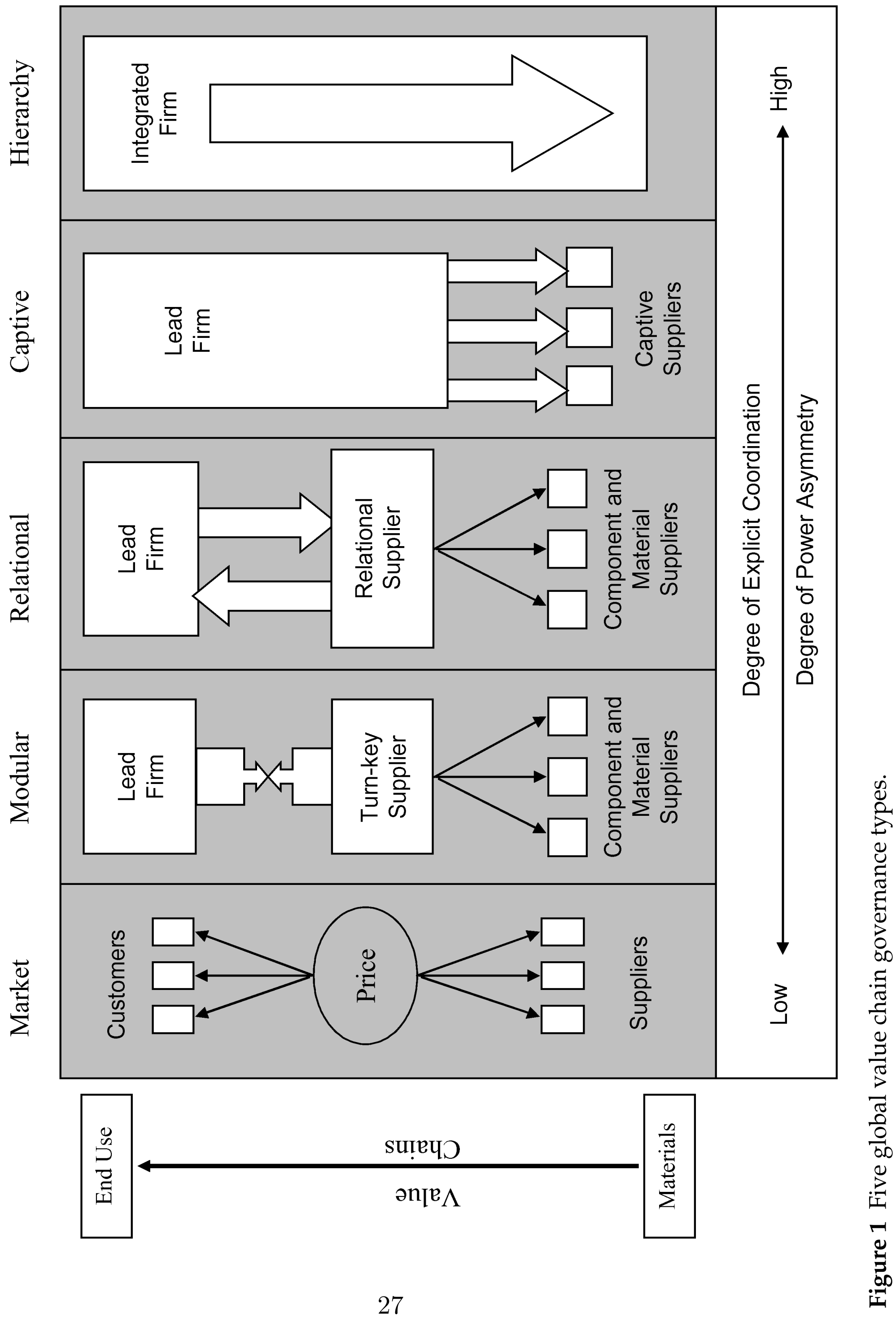

Figure 1: Adopted from Gereffi, Humphrey and Sturgeon (2005).

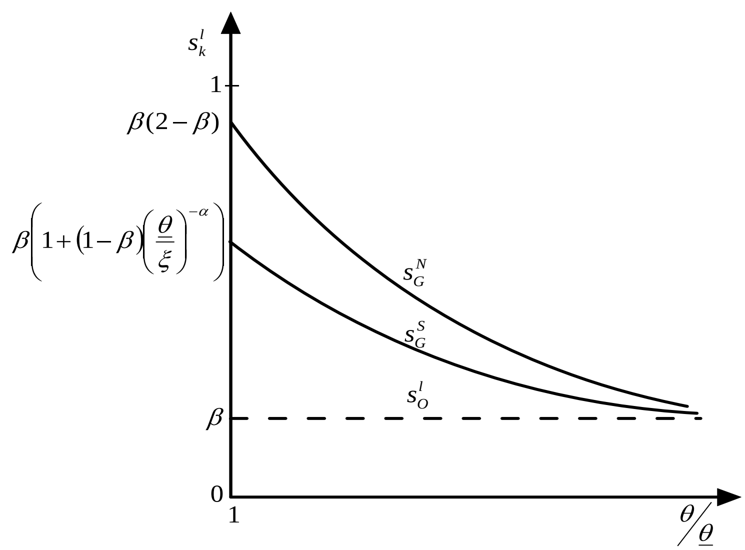

Figure 2: Intermediate good firm's surplus share under outsourcing.

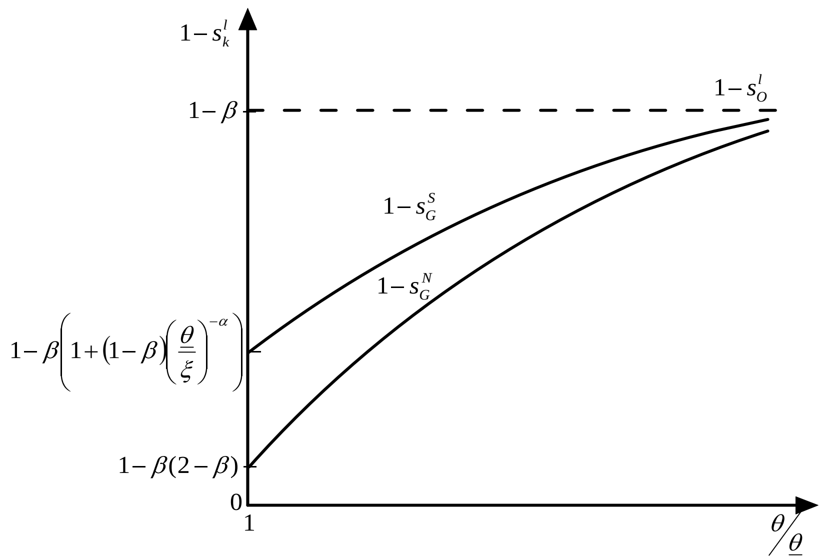

Figure 3: Hold-up friction under outsourcing.

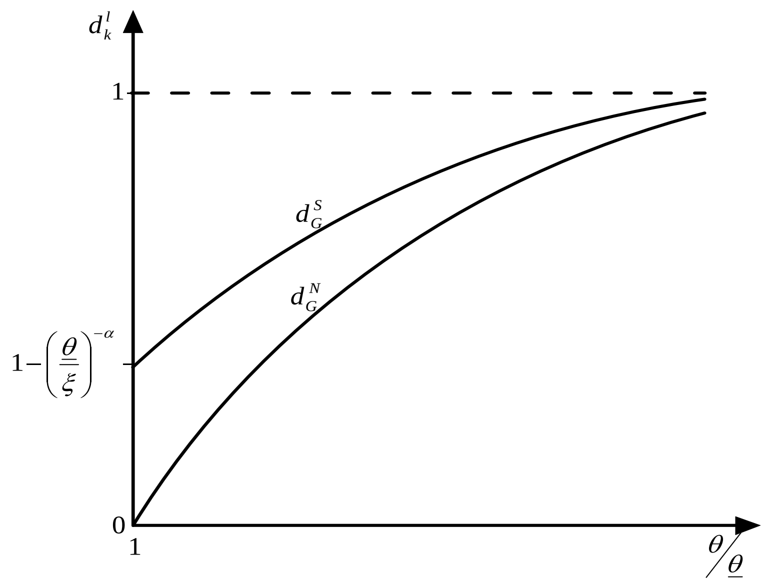

Figure 4: Degree of input specificity under outsourcing

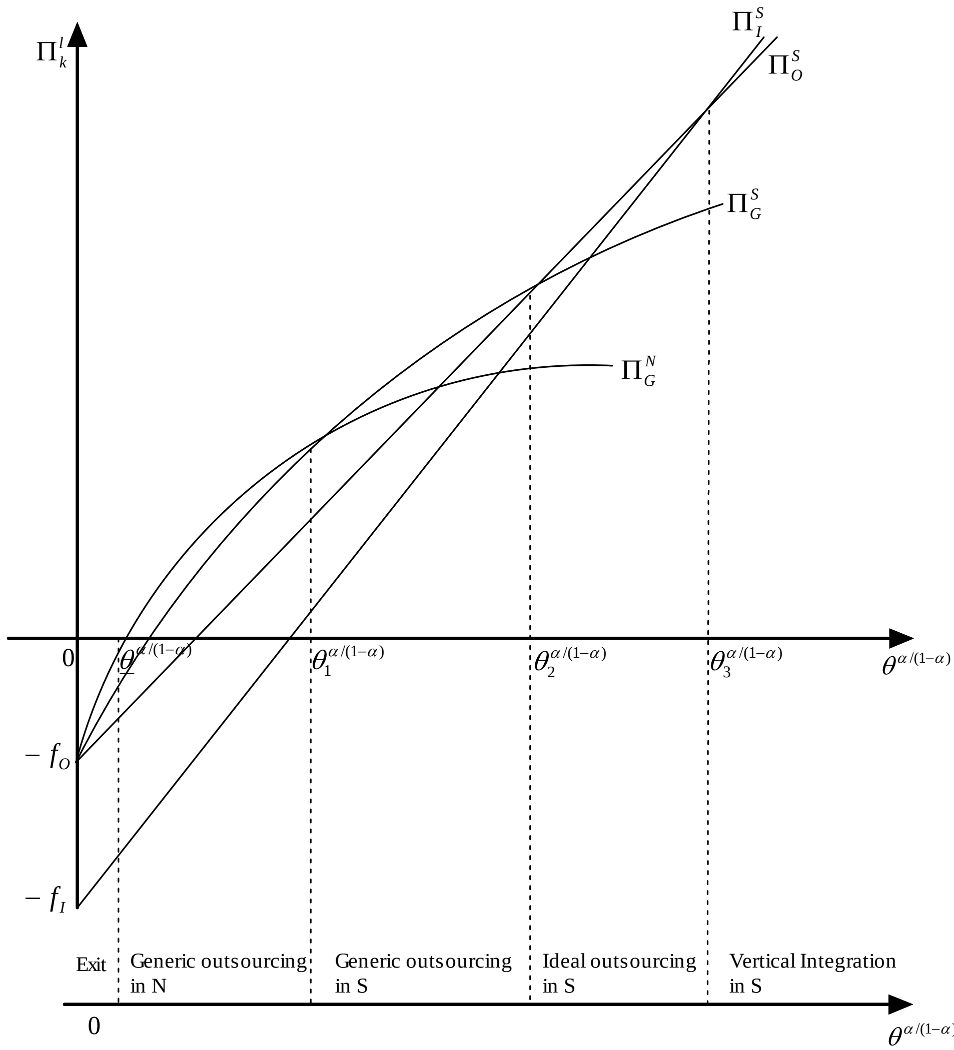

Figure 5: Equilibrium Sorting Pattern