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 ownership structure and location of production. We demonstrate that in an industry where inputs are not completely specific, the hold-up friction under outsourcing increases with a firm's productivity. If ex post coordination costs are higher in the South than North, our model predicts that low productivity firms choose to outsource to the North, while high productivity firms choose to outsource to the South.

JEL Codes: F23, F12.

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

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1 Introduction

With the availability of more detailed firm-level data, firm heterogeneity has become the 'new kid on the block' in the international trade literature. Empirical studies have unveiled a systematic relationship between productivity and a firm's location of production. Head and Ries (2003) and Girma, Kneller and Pisu (2005), for example, found that the productivity of firms engaged in FDI is higher than the productivity of firms that do not. Similarly, Tomiura (2005) found that high productivity firms choose to outsource internationally, while 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, 2006) and Grossman, Helpman and Szeidl (2005) map the property rights theory of Grossman and Hart (1986) and Hart and Moore (1990) into a two-country industry-equilibrium trade model with heterogeneous firms. The studies suggest that fixed costs differences between organizational forms play a defining role on firms' sorting patterns according to their productivity level. If the fixed cost of outsourcing internationally is larger than outsourcing domestically, then only the most productive firms in component-intensive industries outsource 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. Second, there is no empirical evidence 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 cost each period to maintain a presence in foreign markets.

This paper explores an alternative explanation for the relationship between productivity and a firm's organizational form that is based on ex post cost differences rather than ex ante fixed cost differences. Our point of departure is the recent international trade literature dealing with incomplete contracts between firms in the provision of specialized inputs. Counter to the theoretical studies mentioned above, we assume that inputs are not

[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.

completely specialized so that intermediate good firms can use a fraction of their inputs for an alternative use if the original outsourcing relation breaks down.[2] In an industry with heterogeneous final good firms, we find that a final good firm's productivity affects the hold-up friction he faces under outsourcing. As the final good firm's productivity rises, the intermediate good firm's outside option decreases relative to the revenue that can be created within the original outsourcing relation. As a result, the hold-up friction that a final good firm faces rises with his productivity level.

We introduce this framework into a two-country industry-equilibrium model where final good firms are all located in the North and intermediate good firms can be located in both the North and South. The North and South differ along two dimensions. First, wages are lower in the South than in the North. Second, the ex post cost of coordinating with a new partner is higher in the South than in the North so that Southern intermediate good firms ex post have a smaller fraction of their inputs at their disposal than Northern intermediate good firms. This difference in ex post coordination cost implies that final good firms face a larger hold-up friction when outsourcing to the South than outsourcing to the North. As we shall show, this difference in hold-up friction between outsourcing to the North and South will decline with the final good firm's productivity. In line with Tomiura's (2005) empirical findings, our model thus will predict that less productive final good firms outsource to the North, while more productive final good firms outsource to the South. This sorting pattern occurs in our model 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 identifies the effect of productivity and location of production on the degree of input specificity. Section 5 then describes the equilibrium sorting of firms into different production structures and locations of production. Section 6 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 con-

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

sumers spend a fraction μ of their aggregate income on the industry and have CES preferences for industry products:

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

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 firms in 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 F. Counter to Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2005), this additional fixed cost does not vary across ownership structure and location of production. The existence of the fixed operating cost F entails that only the final good firms with a productivity θ above a certain threshold productivity level $\underline{\theta}$ become active. The firms with $\theta \leq \underline{\theta}$ 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.[3] 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: $\omega^S < \omega^N = 1$.

Contrary to the existing literature, we assume that the inputs are not completely specific to a final good, but rather can be used ex post by any other final good firm at a loss of fraction $1-\tau^l$ of the inputs, where $\tau^l \in [0,1]$. To capture the notion that coordination technology is less developed in the South and that it is more difficult to coordinate with a new partner across borders than within a country, we assume that $\tau^N \geq \tau^S$.

To obtain inputs, each final good firm forms a contract with one of a perfectly elastic supply of potential intermediate good firms in the North or the South. The contract includes an up-front lump-sum transfer t paid by the intermediate good firm and an allocation of the residual rights. Firms in both the North and the South operate in a setting of incomplete contracts, however, implying that the two parties ex ante cannot sign an enforceable contract for the purchase of a specific quantity of inputs at a specific price. Because no enforceable contracts can be signed ex ante, the intermediate and final good firms bargain over the surplus of the relationship after the inputs have been produced, i.e. ex post. We model this ex post bargaining as a Generalized Nash Bargaining game where intermediate good firms have a fixed bargaining share $\beta \in [0,1]$.

Both parties' ex post surplus share in our model is a function of the ownership structure and location of production. Following the property rights approach to the theory of the firm, we assume that final good firms form incomplete contracts with intermediate good firms under both outsourcing (O) and vertical integration (I).[4] The ownership structure affects both parties' outside options differently, thus leading to a different distribution of surplus between the two parties. Under vertical integration, the final good firm has the residual right over the inputs produced by the intermediate good firm and thus has the right to fire him and seize the inputs $x(i)$ if the

[3] This production function conforms to Antràs and Helpman (2004, 2006) special case of a completely input-intensive industry.

[4] Alternatively, we could follow Grossman and Helpman (2002) and Ornelas and Turner (2005) by assuming that inefficiencies due to contract incompleteness can be circumvented under vertical integration. As we discuss in the conclusion, this will not change the central result of our paper.

relation breaks down. Similar to Antràs and Helpman (2004), we assume that firing the intermediate good firm results in a loss of a fraction $1-\delta$ of inputs that can be used for final good production. The intermediate good firm, on the other hand, has no residual rights on the inputs it produces and thus has no outside option. Under outsourcing, a failure to reach an agreement may leave the intermediate good firm with a positive outside option since it can form a new relationship with one of the idle final good firms with $\theta \leq \underline{\theta}$ by offering inputs $\tau^l x(i)$. The final good firm, however, has no outside option since he will be searching in vain for another intermediate good firm. As we will see below, the difference in ex post outside options between vertical integration and outsourcing implies that the ex post surplus share of the intermediate good firm will be larger under outsourcing than vertical integration.

The location of production also affects both parties' ex post surplus share. Since $\tau^N \geq \tau^S$, the inputs produced by Northern intermediate good firms are more specific than the inputs produced by Southern intermediate good firms. As a result, the intermediate good firm's ex post outside option and ex post surplus share will be higher under outsourcing to the North than outsourcing to the South.

The model can be summarized by the following sequences of moves: in period 0, each final good firm i decides whether it enters the market. If he enters, he incurs a fixed cost F_e to have his productivity level $\theta(i)$ realized. In period 1, 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 by simultaneously choosing the ownership structure $k \in K = \{I, O\}$ and location of input production $l \in L = \{N, S\}$. In period 2, the final good firm signs a contract with an intermediate good firm and the intermediate good firm pays the lump-sum transfer. In period 3, the intermediate good firm produces its inputs. In period 4, there is generalized Nash 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. In our analysis below, we will solve for the optimal organizational form through backward induction. We will denote periods 0, 1 and 2 as ex ante to reflect that they take place prior to input production, and period 4 as ex post to reflect that it takes place after input production.

3 Hold-Up Friction

We start by calculating each party's ex post surplus share that results from the generalized Nash bargaining in period 4, and subsequently solve the model backwards. To simplify notation, we from now on will drop the i's and refer to a firms "ex post outside option" as its outside option. 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 the remaining share of the surplus

$$v_k^l + \beta\left(R_k^l - v_k^l - V_k^l\right). \tag{4}$$

To solve for each party's surplus share for the various organizational forms, 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 outside option as the deviation payoff when a relationship breaks down between an intermediate and final good firm, taking as given the continuance of all other relationships.

Vertical Integration. Following the property rights theory of the firm, we assume that under vertical integration to the North (I, N) and South (I, S), the final good producer has the residual rights over the inputs produced by the intermediate good firm. If a relationship breaks down, he therefore has the power to fire the intermediate good firm and seize a fraction δ of inputs. As a result, its outside option $V_I^l = \delta^\alpha R_I^l$. The intermediate good firm, however, has no outside option since it has no residual rights over the inputs it produces. As a result, $v_I^l = 0$. Thus, for the organizational forms (I, l), we have:

$$V_I^l = \delta^\alpha R_I^l \text{ and } v_I^l = 0. \tag{5}$$

Outsourcing. Under outsourcing to the North (O, N) and South (O, S), the intermediate good firm may have a positive outside option. If the original relationship with a final good firm breaks down, an intermediate good firm has the option to negotiate with the threshold final good firm with productivity $\underline{\theta}$ to form a new relationship.[5] The intermediate good firm can then offer his new partner share τ^l of its inputs x and a lump-sum transfer to guarantee the threshold firm's participation. In return, he receives share β of the newly created revenue.[6] The intermediate good firm will only be willing to form such a new relation if it leaves him at least as well off as if he would remain idle after the breakup of the original relation. As is shown in Appendix A, any Northern intermediate good firm regardless of his partner's productivity will be willing to form an ex post relation with the threshold firm if the followig condition holds:

$$\tau^N \geq \left(\frac{1 - \alpha\beta}{1 + \alpha\beta(1-\beta)} \right)^{\frac{1}{\alpha}}. \tag{6}$$

For the remainder of the paper we will focus on industries where equation (6) holds. In Appendix A, we derive that the Northern intermediate good firm in that case will receive a constant fraction of the revenue that could have been generated in the original outsourcing relation R_O^N:

$$v_O^N = \beta \left(\frac{\tau^N \underline{\theta}}{\theta} \right)^{\alpha} R_O^N. \tag{7}$$

Since $\tau^N \geq \tau^S$, Southern intermediate good firms under outsourcing lose a larger fraction of their inputs than Northern intermediate good firms when forming a new relation with the threshold final good firm. This implies that Southern intermediate good firms need to pay a larger lump-sum transfer to guarantee the threshold final good firm's participation in the new relationship. In Appendix A, we show that this higher fixed cost to the Southern intermediate good firm implies that only the Southern intermediate good firms who originally had an outsourcing contract with a sufficiently high

[5] The intermediate good firm can negotiate with any idle final good firm with productivity $\theta \leq \underline{\theta}$. Since the threshold final good firm is the idle firm with the highest productivity level, the intermediate good firm chooses prefers him over the other idle firms.

[6] The assumption that the intermediate good firm receives share β of total revenue in the outside relationship is equivalent to assuming that there is no further separation possible in the outside option. In principle there might be further separations, but for simplicity we take the outside options after the second stage as nill. See Grossman and Helpman (2002) for a similar approach.

productivity firm with $\theta \geq \theta_1$ decide to form a new relation if the original relation breaks down. The other Southern intermediate good firms will remain idle when the original relation breaks down, thus leaving them with no outside option. As such,

$$v_O^S = \begin{cases} 0 & \text{if} \quad \theta < \theta_1 \\ \beta \left(\frac{\tau^S \theta}{\theta}\right)^{\alpha} R_O^S & \text{if} \quad \theta \geq \theta_1 \end{cases} \tag{8}$$

The final good firm under outsourcing to the North and South (O, l) does not have an outside option in our model setup. Since all other independent intermediate good firms that have produced inputs are already tied up in relations with other final good firms, and since there is not sufficient time for new inputs to be produced, the final good firm will be searching in vain for a new partner if the original relationship breaks down.[7] Thus,

$$V_O^l = 0. \tag{9}$$

By inserting equations (5), (7), (8) and (9) into equation (4), we can rewrite the intermediate good firm's ex post surplus share as:

$$s_k^l = \begin{cases} \beta(1-\delta^{\alpha}) & \text{if} \quad (I,l) \\ \beta & \text{if} \quad (O,S) \text{ and } \theta \leq \theta_1 \\ \beta \left(1 + (1-\beta)\left(\frac{\tau^S \theta}{\theta}\right)^{\alpha}\right) & \text{if} \quad (O,S) \text{ and } \theta \geq \theta_1 \\ \beta \left(1 + (1-\beta)\left(\frac{\tau^N \theta}{\theta}\right)^{\alpha}\right) & \text{if} \quad (O,N) \end{cases} \tag{10}$$

As can be seen from equation (10), the intermediate good firm's ex post surplus share s_k^l is a function of both the organizational form and the final good firm's productivity level. First, for a given productivity level of its final good partner, the intermediate good firm's ex post surplus share is higher under outsourcing to the North than under outsourcing to the South and vertical integration to the North and South, in that order. Second, productivity affects the intermediate good firm's ex post surplus share under outsourcing to the North and South. Under outsourcing to the North, an increase in the final good firm's productivity induces his intermediate good partner's outside option v_O^N to decline relative to the revenue that can be created in the original relation R_O^N. As a result, the Northern intermediate good firm's ex post surplus share continuously decreases in his final good

[7] As we discuss in the conclusion, the main results of our analysis continue to hold even if we change this assumption.

partner's productivity. Under outsourcing to the South, productivity first determines whether an intermediate good firm has an outside option. If the final good firm's productivity $\theta < \theta_1$, the Southern intermediate good firm does not have an outside option, thus leaving him with surplus share β. If the final good firm's productivity $\theta \geq \theta_1$, then the intermediate good firm has an outside option. In that case, similar to outsourcing to the North, the intermediate good firm's ex post surplus share continuously decreases in its final good partner's productivity. In Section 4, we will demonstrate that the effect of productivity on the intermediate good firm's ex post surplus share is related to input specificity.

We can now role back the clock to period 3 in which the input provider must decide how many inputs to produce for his partner. When choosing his profit-maximizing level of inputs, the input provider foresees a potential reward of $s_k^l R$ from producing the amount of inputs x. To produce these inputs, however, he faces variable cost $w^l x_k^l$ and a sunk lump-sum transfer t. In other words, he faces the following profit maximization problem:

$$\max_x \pi_k^l = s_k^l R_k^l - \omega^l x_k^l + t, \tag{11}$$

where s_k^l is defined by equation (10). It is straightforward to derive that, all else equal, the amount of inputs that the intermediate good firm produces is decreasing in the ex post surplus share s_k^l.

Next, we can role back to period 2, which takes place ex ante. In period 2, the final good firm signs an incomplete contract with an intermediate good firm and the intermediate good firm is required to pay a lump-sum transfer t. The final good firms requires the amount of lump-sum transfer from the intermediate good firm that maximizes his profits while guaranteeing the intermediate good firm's participation in the relationship. We assume that the intermediate good sector in both the North and South is sufficiently competitive so that an intermediate good firm's participation constraint is nonnegative profits. The final good firm thus chooses the following lump-sum transfer:

$$\max_t \Pi_k^l = (1 - s_k^l) R_k^{l*} - F + t \tag{12}$$

subject to

$$\pi_k^{l*} = s_k^l R_k^{l*} - \omega^l x_k^{l*} - t \geq 0. \tag{13}$$

The optimal lump-sum transfer t^* allows a final good firm to extract all profits from the intermediate good firm.

If we solve for the optimal lump-sum transfer in equation (13) and insert it into (12), we are left with the profit-maximization problem that the final

good firm faces in period 1 when choosing his optimal organizational form (k^*, l^*):

$$\max_{k\in k, l\in L} \Pi_k^l = R(x_k^{l*}) - \omega^l x_k^{l*} - F, \tag{14}$$

subject to:

$$x_k^{l*} = \text{argmax}_x \left\{ s_k^l R_k^l - \omega^l x_k^l \right\}. \tag{15}$$

In choosing the optimal organizational form, the final good firm needs to take into account the differences in hold-up friction between organizational forms. The severity of the hold-up friction for a firm can be determined by comparing with a complete contracting environment. If contracts are complete, 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 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 1, we use equation (10) to graph the hold-up friction that final good firms under the various organizational forms.

[Figure 1 about here]

In Figure 1, the final good firm's productivity relative to that of the threshold firm is depicted on the x-axis, while the hold-up friction is depicted on the y-axis. Figure 1 suggests that, for a given productivity θ, the hold-up friction that a final good firm faces can be uniquely ranked by organizational form: it increases as we go from outsourcing to the North, to outsourcing to the South and to vertical integration to the North and South, in that order. Second, under outsourcing to the North and South the hold up friction is a function of the final good firm's productivity. Under outsourcing to the South, productivity on the one hand has an inframarginal effect on the hold-up friction. When $\theta \leq \theta_1$, the intermediate good firm has no outside option, thus leading to a high hold-up friction $1-\beta$. As θ rises above θ_1, the hold-up friction jumps to a lower level since the intermediate good firm obtains a positive outside option. On the other hand, it has a marginal effect when $\theta > \theta_1$ since the final good firm's hold-up friction rises with productivity.

[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 that the intermediate good firm pays.

Under outsourcing to the North, a rise in productivity leads to a similar increase in the hold-up friction.

When choosing his organizational form, a final good firm does not focus on the level of hold-up friction, but rather on the difference in hold-up friction between organizational forms. As can be seen from Figure 1, the difference in hold-up friction between outsourcing to the North and South decreases as a final good firm's productivity rises. Below, we will demonstrate that the effect of productivity on the difference in hold-up friction between outsourcing to the North and South will be a key factor that drives the organizational form that firms adopt. We therefore state this in the following proposition:

Proposition 1 *All else equal, the difference in hold-up friction between outsourcing to the North (O, N) and outsourcing to the South (O, S) declines as the final good firm's productivity θ rises.*

Proof. Follows from combining the definition of hold-up friction as $1 - s_k^l$ and equation (10). ■

4 Input Specificity

To understand the impact of productivity on the hold-up friction under outsourcing to the North and South, it is instructive to calculate the degree of input specificity under outsourcing to the North and South. We define *the degree of input specificity* d_O^l as the difference between the total revenue that can be created with an input within a buyer-seller relationship R_O^l and the total revenue that can be created with that input in the outside option $\underline{R}_O^l$ as a share of total revenue within the buyer-seller relationship:[9]

$$d_O^l = \frac{(R_O^l - \underline{R}_O^l)}{R_O^l}.$$

If $d = 0$, then there is no input specificity since the inputs are equally valuable within and outside the buyer-seller relationship. If $d = 1$, then there is complete input specificity since inputs are worthless in the outside relationship. In our model, the degree of input specificity under outsourcing equals

$$d_O^l = \begin{cases} 1 & \text{if} \quad (O,S) \text{ and } \theta \leq \theta_1 \\ 1 - \left(\frac{\tau^S \underline{\theta}}{\theta}\right)^{\alpha} & \text{if} \quad (O,S) \text{ and } \theta \geq \theta_1 \\ 1 - \left(\frac{\tau^N \underline{\theta}}{\theta}\right)^{\alpha} & \text{if} \quad (O,N) \end{cases} \tag{16}$$

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

In Figure 2, we graph the degree of input specificity for the various organizational forms by depicting the final good firm's productivity relative to that of the threshold firm on the x-axis, and the hold-up friction on the y-axis.

[Figure 2 about here]

As is demonstrated in equation (16) and depicted in Figure 2, the degree of input specificity is not only a function of an input's technological characteristics, but also of the location of production and the final good firm's productivity level. The location of input production affects the degree of input specificity through the difference in ex post coordination cost τ^l. Since $\tau^N \geq \tau^S$, Southern intermediate good firms lose a larger fraction of their inputs in their outside option than Northern intermediate good firms. As a result, for a given level of productivity, outsourcing to the South leads to a larger degree of input specificity than outsourcing to the North.

For a given organizational form, the final good firm's productivity also affects the degree of input specificity. As a final good firm's productivity rises, the revenue that can be created within the original relation R_O^l rises relative to the revenue that can be created in the outside option $R_{\underline{O}}^l$. As a result, the degree of input specificity also rises.

Finally, the interaction between ex post coordination costs τ^l and final good firm θ implies that the difference in input specificity between outsourcing to the North and South declines with a final good firm's productivity. As such, we can directly link proposition 1 to the degree of input specificity.

5 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 (15) and insert x_k^{l*} into equation (14), we can derive the final good firm's profit maximization problem:

$$\max_{k \in K, l \in L} \Pi_k^l(\theta^{\frac{\alpha}{1-\alpha}}) = A\theta^{\frac{\alpha}{1-\alpha}} \left(1 - \alpha s_k^l\right) \left(\frac{\alpha s_k^l}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}} - F, \tag{17}$$

where s_k^l is given by equation (10). As can be seen from equations (10) and (17), the choice of organizational form not only depends on the ensuing hold-up friction $1 - s_k^l$, but also on the wage difference ω^l between the North and South. The lower wages in the South act as an incentive for

final good firms to source their inputs from the South. In Appendix B, we derive a final good firm's profit as a function of its productivity for all feasible organizational forms when ω^S is sufficiently small. This permits us to describe how final good firms' sorting into different organizational forms depends on productivity θ. Let θ_2 denote the productivity level for which $\Pi_O^N = \Pi_O^S$. The following proposition then holds:

Proposition 2 *Outsourcing in the North is optimal for final good firms with $\theta \in [\underline{\theta}, \theta_2]$; outsourcing to the South is optimal for final good firms with $\theta \in [\theta_2, \infty]$.*

Proof. See Appendix B. ■

In the proof of Proposition 2, we first demonstrate that vertical integration in the North (I, N) is always dominated by outsourcing to the North (O, N) and vertical integration in the South (I, S) is always dominated by outsourcing to the South (O, S). Intuitively, this is because the hold-up friction is larger under integration than under outsourcing, while there is no difference in wages. This result is in line with Antràs and Helpman's finding (2004) that all firms choose outsourcing in input-intensive industries. Next, we demonstrate that under outsourcing to the North (O, N) and South (O, S), the profit function Π_O^N is an increasing and concave functions in $\theta^{\frac{\alpha}{1-\alpha}}$. The profit function Π_O^S consists of two segments. For $\theta^{\frac{\alpha}{1-\alpha}} \leq \theta_1^{\frac{\alpha}{1-\alpha}}$, Π_O^S is a linear and increasing function of $\theta^{\frac{\alpha}{1-\alpha}}$. For the segment $\theta^{\frac{\alpha}{1-\alpha}} \geq \theta_1^{\frac{\alpha}{1-\alpha}}$, it is an increasing and concave function of $\theta^{\frac{\alpha}{1-\alpha}}$. Finally, we show that for low productivity levels, $\Pi_O^{N\prime} > \Pi_O^{S\prime}$, while for high productivity levels $\Pi_O^{N\prime} < \Pi_O^{S\prime}$. Since the fixed operating cost F is identical between organizational forms, these characteristics of the profit functions allow us to derive the sorting pattern of firms depending on their productivity level.

In Figure 3, we graphically analyze the role of productivity on the optimal organizational form by depicting $\theta^{\frac{\alpha}{1-\alpha}}$ on the x-axis and Π_k^l on the y-axis. Consistent with proposition 2, we find that outsourcing to the North (O, N) is optimal for $\theta \in [\underline{\theta}, \theta_2]$ and outsourcing to the South (O, S) is optimal for $\theta \geq \theta_2$.

[Figure 3 about here]

The intuition behind the sorting pattern comes from proposition 1. For low productivity firms, the large difference in hold-up friction between outsourcing to the North and South provides a disincentive against sourcing from

the South that outweighs the benefit of lower wages in the South. For high productivity firms, the difference in hold-up friction is more limited, and it thus becomes worthwhile to shift production to the South to take advantage of lower wages. Proposition 2 is consistent with Tomiura's (2005) empirical evidence that high productivity firms choose international outsourcing, while low productivity firms choose domestic outsourcing.

6 Conclusion

This paper has provided an alternative theory why only the most productive firms in input-intensive industries outsource internationally. We have demonstrated that in industries where inputs are not completely specific, the hold-up friction that firms face under outsourcing rises with their productivity level. If firms face higher ex post coordination costs when operating in the South instead of the North, then our model predicts that low productivity firms will outsource to the North, while high productivity firms outsource to the South. This result holds even if fixed costs are identical for all organizational forms.

The driving force behind this sorting pattern is that in a two-country industry-equilibrium model, the degree of input specificity in an outsourcing relation is not only a function of an input's technological characteristics, but also a function of the location of input production and the final good firm's productivity level. Higher ex post coordination costs in the South than the North imply that inputs sourced from the South are more specific than those sourced from the North. Heterogeneity in the final good firms' productivity level implies that inputs are more specific in outsourcing relations with high productivity firms than in outsourcing relations with low productivity firms. The interaction of both effects imply that the difference in input specificity — and hold-up friction — between outsourcing to the North and South declines with a final good firm's productivity.

The results of our model are robust to changes in a number of model assumptions. First, our key result that only the more productive firms outsource internationally is not contingent on the assumption that final good firms have no outside option under outsourcing. Specifically, our sorting pattern continues to hold if we assume that final good firms can purchase a fraction of the inputs from the spot market in their outside option. Second, if we follow Grossman and Helpman (2002) and Ornelas and Turner (2005) by assuming that vertical integration circumvents the hold-up friction but leads to higher fixed cost, we continue to find that firms outsourcing to

the South are more productive than firms outsourcing to the North. We in that case obtain the additional result that the most productive firms choose vertical integration in the South. Finally, our key result will be reinforced if we assume that intermediate good firms face a higher ex post fixed search cost in the South than the North.

Appendix A: Derivation of v_o^l

In the calculation of the intermediate good firm's outside option under outsourcing to the North and South, we in a first step derive the intermediate good firm's surplus share if he forms an outside relation with the threshold final good firm with $\underline{\theta}$. In the second step, we derive the condition under which any intermediate good firm in the North regardless of his final good partner's productivity level is willing to form such an outside relation. In the third step, we analyze the Southern intermediate good firms' outside options.

Step 1. Let x denote the amount of inputs that the intermediate good firm has produced for the original outsourcing relationship. If an outside relation is formed with the threshold firm, equation (3) suggests that the threshold firm (with productivity $\underline{\theta}$) will be able to produce

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

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

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

We assume that both parties face zero outside options in their outside option. As a result, the intermediate good firm will obtain surplus share $\beta\underline{\mathrm{R}}$ from this relationship, while the threshold final good firm obtains $(1-\beta)\underline{\mathrm{R}}$.[10] Using equations (A-1) and (A-2), the intermediate good firm's outside option equals

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

We can use equations (2) and (3) to derive the revenue that could have been created in the 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 thus express v as a function of R:

$$v_O^l = \beta \left(\frac{\tau^l \underline{\theta}}{\theta} \right)^{\alpha} R_O^l. \tag{A-5}$$

[10] See footnote 5 for details.

From equation (A-5), the intermediate good firm's outside option under outsourcing to the North and South is a constant fraction of the revenue that could have been generated in the original relation.

Step 2. Next, we need to determine under which condition any Northern intermediate good firm regardless of his partner's productivity level will be willing to form a new relation with the threshold firm. To form a relation with the threshold firm, the intermediate good firm needs to ensure that the threshold firm has sufficient incentives to participate in the relationship. For this purpose, he will offer the threshold firm a lump-sum transfer T that leaves him with nonnegative profits:

$$\max_{T} \pi_k^l = \beta A^{1-\alpha}(\tau^l \underline{\theta} x_O^l)^\alpha - T \tag{A-6}$$

subject to

$$\underline{\Pi}_O^l = (1-\beta)A^{1-\alpha}(\tau^l \underline{\theta} x_O^l)^\alpha - F + T \geq 0. \tag{A-7}$$

By plugging (A-7) into (A-6), the intermediate good firm in the outside option ends up with profits $\underline{\mathrm{R}} - F$. He will only agree to form a relation with the threshold firm in the outside option if it leaves him at least as well off as when he remains idle after the original relation breaks down. The intermediate good firm thus will only form a new relation with the threshold final good firm if:

$$A^{1-\alpha}(\tau^l \underline{\theta} x_O^l)^\alpha - F \geq 0. \tag{A-8}$$

To derive the parameter range under which condition (A-8) holds for all intermediate good firms, we need to solve for the remaining stages of the model. To simplify the exposition of the paper, we will use these results at this point to derive the condition under which all Northern intermediate good firms are willing to form a new relation with the threshold firm. This in no way affects the rigor of the model. By using equation (15), we can solve for x_O^{l*} and insert it into equation (A-8):

$$A \geq \frac{F}{\left(\alpha \theta^\alpha s_O^l\right)^{\frac{\alpha}{1-\alpha}} \left(\tau^l \underline{\theta}\right)^\alpha}. \tag{A-9}$$

It is straightforward to derive that a large τ^l, s_O^l and θ guarantees that equation (A-9) holds. Next, we can solve for A by taking advantage of the threshold firm's special characteristic that he ex ante is indifferent between being active in the market and remaining idle. From equation (14), this implies that for the threshold firm

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

We show in proposition 2 that when outsourcing to the North is chosen by at least one final good firm, then the least productive active final good firm chooses outsourcing to the North. This implies that if the threshold firm were active, he would have chosen outsourcing to the North as organizational form. By using equations (10) and (15), we can thus derive that

$$A = \frac{F}{\left(\alpha \underline{\theta} \underline{s}_O^N\right)^{\frac{\alpha}{1-\alpha}} \left(1 - \alpha \underline{s}_O^N\right)}, \tag{A-11}$$

where $\underline{s} = \beta(1 + (1-\beta)\tau^{N\alpha})$ is the surplus share of the intermediate good firm that ex ante would have formed a relation with the threshold firm. If we insert equation (A-11) into equation (A-10), it is straightforward to derive that even the Northern intermediate good firm whose final good partner has the lowest productivity in the market $\underline{\theta}$ will be willing to form an outside relation with the threshold firm if the following condition holds:

$$\tau^{N\alpha} \geq \frac{1 - \alpha\beta}{1 + \alpha\beta(1-\beta)} \tag{A-12}$$

In that case, all Northern intermediate good firms have the outside option given in equation (A-5).

Step 3. Under condition (A-12), not necessarily all Southern intermediate good firms will be willing to form an outside relation with the threshold firm. To see this, we can notice that for Southern intermediate good firms condition (A-9) is less likely to hold than for Northern intermediate good firms since $\tau^S \leq \tau^N$ and $s_O^S \leq s_O^N$. As a result, it might be the case that Southern intermediate good firms with low productivity final good partners are not willing to form an ex post relation with the threshold firm if the original relation breaks down. Denote θ_1 as the final good partner's productivity at which a Southern intermediate good firm is indifferent between remaining idle and forming an outside option with the threshold final good firm. In that case, Southern intermediate good firms that originally are partnered with $\theta < \theta_1$ have no outside option, while Southern intermediate good firms that are originally partnered with $\theta \geq \theta_1$ form an outside option.

Appendix B: Proof of Proposition 2

In this appendix, we will first demonstrate that vertical integration to the North and South (O,l) are 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.

Vertical integration to the North and South (O,l) are never optimal strategies because they are always dominated by outsourcing to the North and South (O,l), respectively. This is because while wages are identical, the hold-up friction for a final good firm with productivity θ under vertical integration is higher than under outsourcing.

For the organizational forms outsourcing to the North and South (O,l) we need to analyze the characteristics of their profit functions $\Pi_k^l(\theta^{\frac{\alpha}{1-\alpha}})$. From equations (10) and (17), we can derive the shapes of the final good firms' profit functions Π_O^N and Π_O^S:

$$\Pi_O^{l\prime} = A\left(1-\alpha\left(\frac{s_O^l-\beta}{s_O^l}+\beta\right)\right)\left(\frac{\alpha s_O^l}{\omega^l}\right)^{\frac{\alpha}{1-\alpha}}, \tag{B-1}$$

and

$$\Pi_O^{l\prime\prime} = -\alpha A\left(\frac{\alpha s_O^l}{\theta\omega^l}\right)^{\frac{\alpha}{1-\alpha}}\frac{s_O^l-\beta}{s_O^{l2}}\left(\left(1-\alpha-\alpha\beta\right)s_O^l+\left(2\alpha-1\right)\beta\right). \tag{B-2}$$

Equations (B-1) and (B-2) imply that the final good firms' profit function Π_O^N is an increasing and concave function of $\theta^{\frac{\alpha}{1-\alpha}}$. The profit function Π_O^S consists of two segments. For $\theta^{\frac{\alpha}{1-\alpha}} \leq \theta_1^{\frac{\alpha}{1-\alpha}}$, Π_O^S is a linear and increasing function of $\theta^{\frac{\alpha}{1-\alpha}}$. For the segment $\theta^{\frac{\alpha}{1-\alpha}} \geq \theta_1^{\frac{\alpha}{1-\alpha}}$, it is an increasing and concave function of $\theta^{\frac{\alpha}{1-\alpha}}$.

It is straightforward to derive that if ω^S is not too small, $\Pi_O^{N\prime} > \Pi_O^{S\prime}$ for low $\theta^{\frac{\alpha}{1-\alpha}}$, while $\Pi_O^{N\prime} < \Pi_O^{S\prime}$ for high $\theta^{\frac{\alpha}{1-\alpha}}$. Since the fixed operating cost is identical for all organizational forms, these characteristics of the profit functions allow us to graphically analyze the sorting pattern of firms. As is demonstrated in Figure 5, the following sorting pattern occurs: outsourcing to the North is optimal for final good firms with $\theta \in [\underline{\theta}, \theta_2]$; outsourcing to the South is optimal for final good firms with $\theta \in [\theta_2, \infty]$.

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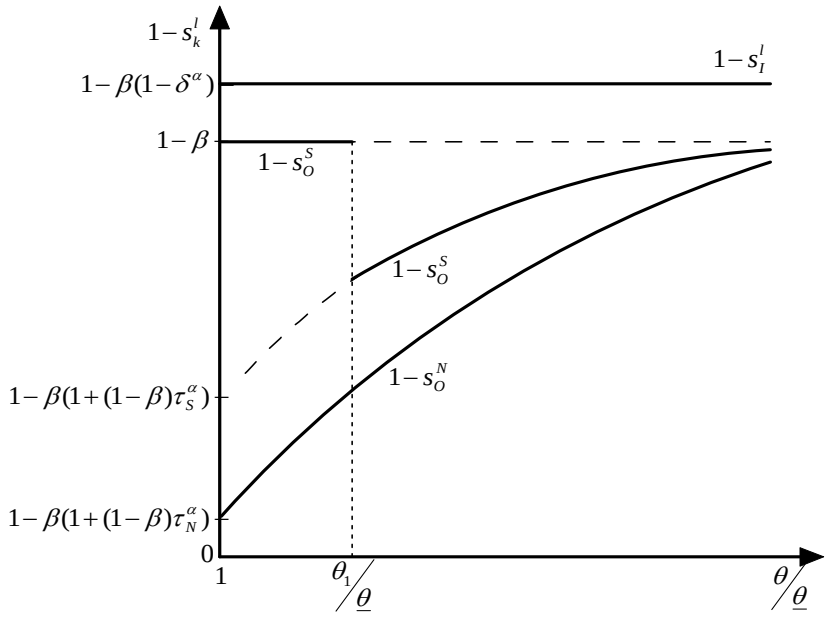

Figure 1: Hold-up friction under outsourcing.

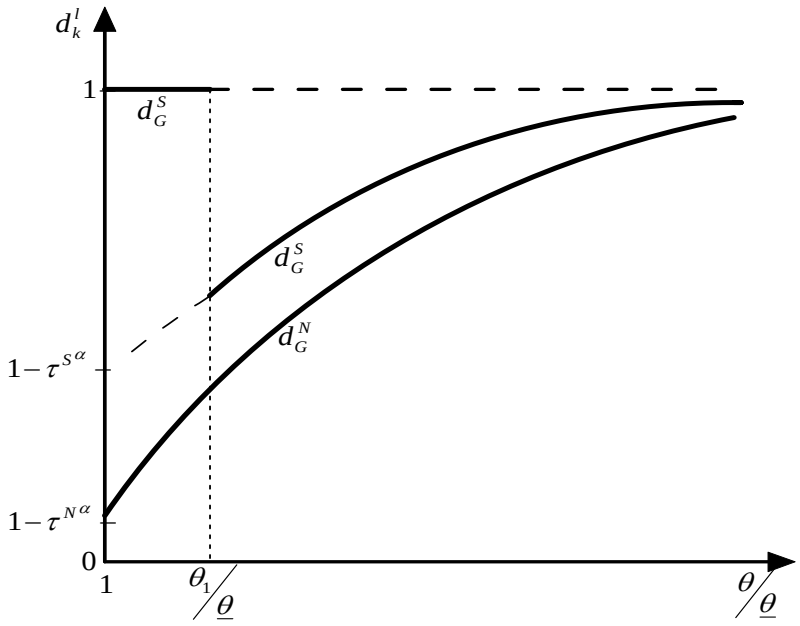

Figure 2: Degree of input specificity under outsourcing

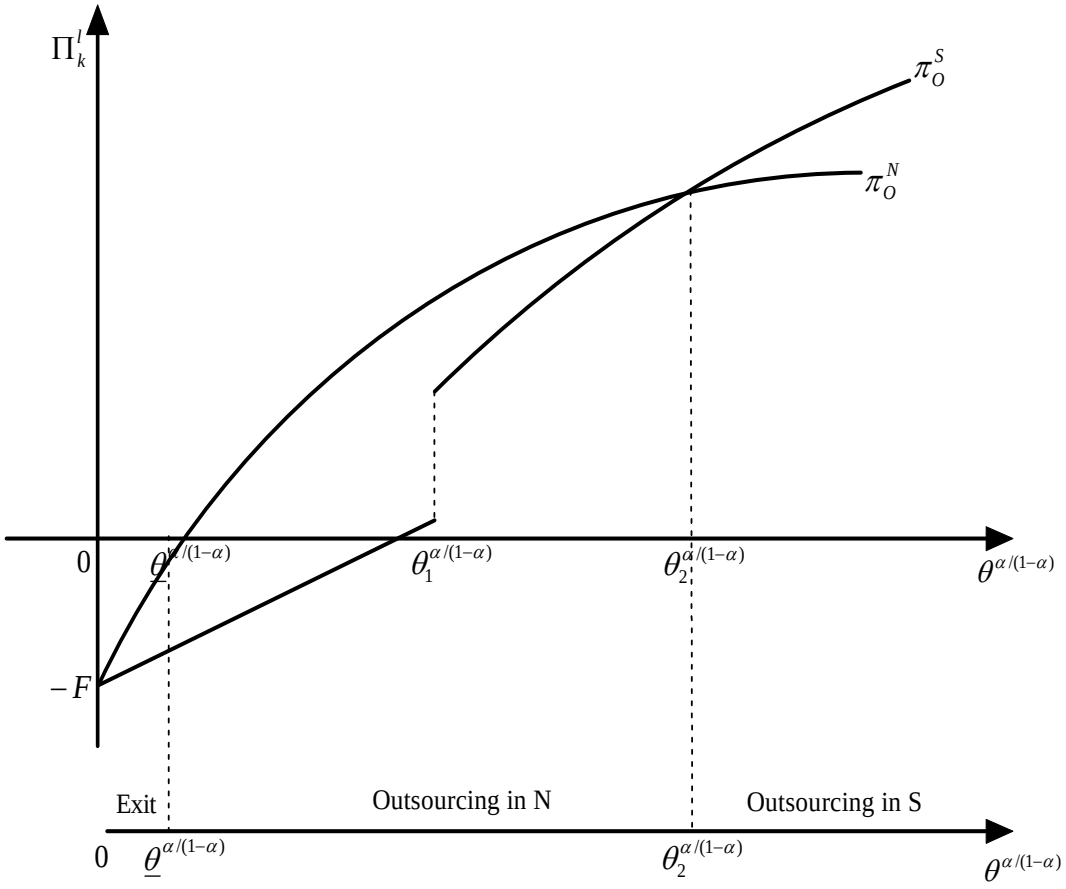

Figure 3: Equilibrium Sorting Pattern