Sourcing, Technology Transfer, and International Trade

by

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Relative to the multinational headquarters in the US and Western Europe, the massive number of producers that these countries employ abroad have received relatively little attention in the literature. My research adds to this body of knowledge by specifically studying (1) who those producers are and (2) what technologies they use.

To address question (1), the first chapter develops a theory where the choice between cross-border partnership and within-border partnership depends on the size of the gain through technology transfer from developed-country headquarters, and the second chapter provides empirical evidence. When developing-country producers have heterogeneous productivity, those with medium levels of productivity will gain sufficiently from technology transfer and choose cross-border partnership. In contrast, high- and low-productivity producers will work with their local headquarters, and the low-productivity producers will not be able to sell their products to developed countries at all.

The third chapter addresses question (2) by comparing the productivity of production factors in Chinese electronics producers that are integrated with headquarters from different source countries. It finds that the productivity of skilled labor is higher in those with developed-country headquarters than those with emerging-economy headquarters, while the productivity of unskilled labor shows no such difference.

Dedication

To my parents and wife.

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Contents

Chapter 1

The Choice of Partner: Theory

1.1 Introduction

Consumers in developed countries increasingly rely on goods that are produced abroad. For example, the United States, where television was invented and is watched more than in any other country, currently has no televisions produced domestically. It is apparent that every aspect of a developed economy such as the US involves products "Made in Country X" (where X refers to developing countries such as China, India, or Mexico). Much less well understood is what types of firms in foreign countries are producing for developed countries, namely, "Made **by whom** in Country X." In particular, information on the productivity of foreign producers is important, because their productivity determines how efficiently developed countries are served.

The first chapter of my dissertation analyzes the productivity of foreign firms that serve developed countries. First, I develop a theory that characterizes how producers in a foreign country (such as China) interact with headquarters in a home country (such as the US). A foreign producer faces a trade-off between the productivity gain generated by the home headquarter's technology transfer and the coordination costs resulting from cross-border differences in machinery specifications, regulations, management routines, and cultures. As an alternative to this cross-border partnership, the foreign producer also has the option of partnering with its local headquarter. From the foreign producer's perspective, the advantage of cross-border partnership over within-border partnership decreases if the foreign producer has a higher level of initial productivity.

The model shows that foreign producers (such as those in China) with mid-range initial productivity are the firms that engage in cross-border partnership. At mid-range level of productivity, the gains from technology transfer outweigh the frictions involved in cross-border coordination, such that cross-border partnership generates sufficient profits for both home headquarters and foreign producers. Unlike these mid-range producers, foreign producers with high levels of initial productivity cannot garner sufficient profits for themselves from technology transfer. Likewise, foreign producers with low productivity cannot generate sufficient profits for home headquarters and thus are not selected for cross-border partnership. As a result, foreign producers with either high or low productivity engage in within-border partnership.

The model also shows that foreign producers with high initial productivity serve both their local market (such as China) and the market of the developed-country headquarter (such as the US), while those with low productivity serve only their local market because they cannot afford the fixed cost of exporting;[1] moreover, among foreign producers that undertake cross-border partnership, those with relatively high productivity are vertically integrated with their headquarters, while those with relatively low productiv-

[1] The relationship between producer and headquarter in the model is vertical; see e.g., Hanson, Mataloni, and Slaughter (2005), and Hummels, Ishii, and Yi (2001) for discussions on vertical fragmentation of production. In this arrangement, cross-border production primarily serves the headquarter's local market (such as the US). In an extension of the model, I show the same findings when cross-border partnership serves other markets as well.

ity operate at arm's length with their headquarters. This follows because, compared to arm's length, vertical integration has the advantage of more effective technology transfer and easier coordination despite higher fixed costs.

The rest of the thesis is organized as follows. Section 1.2 discusses the contributions of my study to the literature. Section 1.3 presents the model and discusses its four predictions (Propositions 1–4). Section 1.4 checks the robustness of the model. After a brief introduction (Section 2.1), Chapter 2 first describes the dataset (Section 2.2), then tests the four predictions (Sections 2.3–2.6), and finally concludes Chapters 1–2 (Section 2.7).

1.2 Literature

This section discusses how Chapter 1 and Chapter 2 link to the literature. First of all, my study belongs to the family of research on multinational practice in international trade. Multinational practice was not considered in the literature until the 1980s by the pioneer works of Helpman (1984) and Markusen (1984). Helpman (1984) and Markusen (1984) examine vertical and horizontal multinational operations, respectively. The vertical case usually results from factor-price differences across countries (e.g., between developed and developing countries), and the horizontal case is common among developed countries where multinational headquarters use foreign subsidiaries to undertake both production and distribution. These two studies became the benchmark approaches in the literature (see, e.g., Helpman and Krugman (1985), Horstmann and Markusen (1987), Brainard (1997), and Markusen and Venables (2000)).

In the past decade, productivity heterogeneity of firms is introduced into the international literature (e.g., Bernard, Eaton, Jensen, and Kortum, 2003; Bustos, 2011; Costantini and Melitz, 2008; Melitz, 2003; Melitz and Ottaviano, 2008; and Yeaple, 2005), and the two benchmark approaches are extended accordingly. For instance, Antras and Helpman (2004, 2008) in the vertical approach, and Chen, Horstmann, and Markusen (2008), Helpman, Melitz, and Yeaple (2004), and Yeaple (2009) in the horizontal approach. My study focuses on the vertical case, while it can be extended to account for horizontal case as discussed later. Having made clear the big picture, I next move on to how my study contributes to the literature in four sub-directions.

First, my study develops a framework that allows producers to endogenously choose headquarters. This goes beyond the literature in which producers merely wait to be selected and the selection is unilaterally made by headquarters. In my model, producers and headquarters each select the other, so that cross-border partnership forms only if the producer also finds this type of partnership to be more profitable than working with its local partner.

Taking producers' choices into account is important because the efficiency of multinational practice depends on which kind of foreign producers are employed. To date, it remains unclear what level of productivity they have ex ante (before working with multinational headquarters) and ex post (after working with multinational headquarters). My study finds that one fourth of the productivity premium of Chinese offshore producers relative to Chinese producers that do not export can be attributed to their difference in initial productivity. Put differently, offshore producers turn out more productive than non-offshore producers that do not export, not only because of the technology transfer offshore producers **ex post** receive, but also because they are **ex ante** more productive.

At this point, it is noteworthy that in my study a foreign producer is a production facility that exists regardless of which partner to work with, a local headquarter or a foreign one. This is easy to understand if the headquarter and producer stay at arm's length; namely, they undertake transactions with each other but remain standing alone. But this study's findings also carry over to the scenario in which the producer and the headquarter are vertically integrated; that is, the producer becomes a subsidiary of the headquarter if it chooses to work with the headquarter. The subsidiary remain existent even if not taken by a specific headquarter, because it can still be integrated by another headquarter. This "independence" of subsidiaries from headquarters was first introduced by Antras and Helpman (2004, 2008), based on the idea that producers can be thought of as managers.

The second contribution is to provide insights on the frictions between producers and headquarters that exist in cross-border partnership. The transfer of technologies (or knowledge capital, as in Carr, Markusen, and Maskus (2003)) from headquarters to producers is usually assumed to be frictionless in the literature. The transfer could be frictional as argued by Arrow (1969), but the friction remains not well understood, because such friction is largely conceptual and cannot directly be observed in the data. Recent studies infer their existence from their presentations. There is evidence that US multinational headquarters substitute for error-prone direct communications with offshore producers by exporting intermediates that embody technologies (Keller and Yeaple, 2010) and vertically integrate their foreign partners if the offshore tasks are complicated (Costinot, Oldenski, and Rauch, 2011). This thesis complements these studies by theoretically showing that developing-country producers with high productivity do not choose to work with US multinational headquarters. Notably, if cross-border partnership were frictionless, foreign producers with high productivity would always find it profitable to partner with US multinational headquarters. This thesis empirically finds that Chinese producers with high productivity actually choose within-border production, clearly attesting to the existence of frictions in cross-border partnership.

The third contribution is to assess the role of technology transfer in cross-border mergers and acquisitions (M&A).[2] In my model, headquarters in developed countries (such as the US) prefer to partner with foreign producers with mid-range productivity because the technology transfer from headquarters to producers translates into an advantage of the headquarters in contracting. They do not target foreign producers with high productivity because, compared to those with mid-range or low productivity, producers with high productivity have better alternative options and thus demand better offers (i.e., profit shares). When partnering with producers with mid-range productivity, headquarters do not need to offer much profit share, as technology transfer from the headquarters makes their offers sufficiently attractive. This advantage in contracting also exists if foreign producers have low productivity, but in that case developed-country headquarters cannot garner enough profits and thus choose to work with their local producers.[3]

Finally, this study is also closely linked to the studies on the effect of multinational practices on the host country (e.g., Markusen and Venables, 1999; Rodriguez-Clare, 1996). The literature has investigated two effects: first, host-country headquar-

[2] For studies on cross-border M&A, see, e.g., Neary (2007), Nocke and Yeaple (2007), and Spearot (2010).

[3] This model does not consider bi-sourcing, i.e., a home headquarter works with both a home producer and a foreign producer; see Du, Lu, and Tao (2009).

ters lose because their local producers turn to multinational headquarters (competition effect), while host-country producers win because they have the freedom to choose better headquarters (linkage effect). My study models how the two effects come into being given that host-country producers have different productivity. I find that the competition effect exists so long as a host-country headquarter's producer meets a productivity threshold, but it dominates the linkage effect only when that producer has mid-range productivity.

1.3 Model

1.3.1 Environment

Consider a world that consists of a host country (H) and a source country (S), which correspond to the foreign country and the home country that were introduced before.[4] Their residual demand functions for differentiated products are, respectively,

$$
\begin{aligned}
y_H &= \Phi_H p_H^{-1/(1-\alpha)}, \\
y_S &= \Phi_S p_S^{-1/(1-\alpha)},
\end{aligned}
\tag{1.1}
$$

where p_l is price, Φ_l measures the demand level, $l \in \{H, S\}$, and α is a parameter that determines the demand elasticity $1/(1-\alpha)$. Production of a differentiated good involves two parties: a producer X and a headquarter Z. There are X and Z in both countries: X_H, X_S, Z_H, and Z_S.

The host-country producer X_H with initial productivity $\theta \in \mathbf{R}_{++}$ can partner with

[4] This change in denomination is to save mental efforts for the author and readers. In technical writing, the term home/foreign may be subconsciously interpreted in different meanings depending on one's nationality background. Unlike home/foreign, source/host is neutral with respect to the reference country.

either a host-country headquarter Z_H (partnership HH) using the production function

$$y_{HH} = \theta x_{SS}, \tag{1.2}$$

or a source-country headquarter Z_S (partnership HS) using the production function

$$y_{HS} = g(\gamma, \mu, \theta) x_{HS}, \tag{1.3}$$

where x_k, $k \in \{HH, HS\}$, is the input of production. In the rest of the chapter, these two partnership types are also referred to as **within**-border and **cross**-border, respectively. Under partnership types HH and HS, X_H produces according to the design provided by Z_H and Z_S, respectively.

In γ, μ, and θ of production function (1.3), only θ is a producer-level parameter. γ denotes technology transfer from Z_S and μ is an inverse measure of coordination difficulty. The combination (γ, μ, θ) determines g, i.e., the final productivity of production. Henceforth, θ and g are referred to as ex-ante and ex-post productivity, respectively. Technology transfer γ and initial productivity θ are complementary in effect, while coordination difficulties reduce both γ and θ. I use the functional form

$$g(\gamma, \mu, \theta) = (\gamma\theta)^{\mu}, \mu \in (0, 1) \tag{1.4}$$

to characterize the fact that both parties' contributions to g, namely γ and θ, are reduced because of coordination difficulties. If either γ or θ doubles, g increases less than double.[5]

Tariff and cross-border transport costs are assumed to be zero at this point, but can easily be incorporated as shown later. In country H, unit cost of the input x is c. Under

[5] The functional form $g(\gamma, \mu, \theta) = \gamma\mu\theta$, which I use later for robustness check, leads to the same results. It is not used here as the benchmark case because it requires constant productivity returns from γ and θ, which contradicts empirical evidence (see Belderbos, Ito, and Wakasugi, 2008).

partnership HH, the output may either serve country H only or both countries H and S. In the latter case a fixed cost f_{EX} (EX stands for "exporting") must be paid to build overseas marketing and sales networks. For convenience, these two cases are regarded as two different partnership types, denoted by (HH,NON) and (HH,B), respectively. Cross-border partnership HS is free from f_{EX} because Z_S knows its local market well.

In country S, unit cost of the input x is $\widetilde{c}$. X_S's only potential partner is Z_S (if they work together, the partnership type is referred to as SS), and the production function thereof is[6]

$$y_{SS} = \widetilde{\theta} x_{SS}, \tag{1.5}$$

where $\widetilde{\theta}$ is a constant, which can be rationalized by considering X_H as the best available producer in Country S.[7] To summarize, Z_S chooses between partnership types HS and SS, while X_H chooses between partnership types (HH,NON), (HH,B), and HS.

The joint profits under the four partnership types are[8]

$$\pi_{HH,NON}(\Theta) = \Psi \Phi_H \Theta, \tag{1.6}$$

$$\pi_{HS}(\Theta) = \Psi \Phi_S \Gamma \Theta^{\mu}, \tag{1.7}$$

$$\pi_{HH,B}(\Theta) = \Psi(\Phi_H + \Phi_S)\Theta - f_{EX}, \tag{1.8}$$

$$\pi_{SS} = \widetilde{\Psi} \Phi_S \widetilde{\Theta}, \tag{1.9}$$

[6] I assume that developed-country headquarters are homogeneous. This removes from the analysis heterogeneity among internationally operating firms in developed countries, which is not crucial given my focus on the trade-off between technology transfer gains and coordination costs that foreign firms face. According to the literature, these headquarters are the most productive firms in developed countries; see, e.g., Antras and Helpman (2004, 2008), and Grossman, Helpman, and Szeidl (2005, 2006).

[7] In other words, cross-border partnership becomes an option when Z_S has exhausted domestic options to raise productivity.

[8] See Appendix A for derivation.

where $\Theta = \theta^{\frac{\alpha}{1-\alpha}}$, $\widetilde{\Theta} = \widetilde{\theta}^{\frac{\alpha}{1-\alpha}}$, $\Gamma = \gamma^{\frac{\alpha\mu}{1-\alpha}}$, $\Psi = (1-\alpha)/(\frac{c}{\alpha})^{\alpha/(1-\alpha)}$, and $\widetilde{\Psi} = (1-\alpha)/(\frac{\tilde{c}}{\alpha})^{\alpha/(1-\alpha)}$. The threshold of Θ for X_H in within-border partnership to serve both countries can be solved by equating $R_{HH,NON}$ to $R_{HH,B}$: $\Theta^* = f_{EX}/(\Psi\Phi_S)$. π_{SS} all goes to Z_S if Z_S chooses partnership SS, because X_S has no outside option. Since $\widetilde{\Psi}$, Φ_S, and $\widetilde{\Theta}$ are all constants, $\widetilde{\pi} \equiv \pi_{SS} = \widetilde{\Psi}\Phi_S\widetilde{\Theta}$ is defined for convenience.

$\Gamma = [\gamma^{\alpha/(1-\alpha)}]^{\mu}$ is technology transfer after factoring in coordination difficulties, which determines whether cross-border partnership is feasible. If Γ is too low, cross-border partnership becomes inferior to within-border partnership because technology transfer is always outweighed by difficulties in cross-border coordination. Formally, Γ is required to satisfy

$$\Gamma > \left[\left(\frac{\widetilde{\Psi}}{\Psi}\right)\left(\frac{\widetilde{\Theta}}{\Theta^*}\right) + \left(\frac{\Phi_H}{\Phi_S}\right)\right]\Omega, \tag{1.10}$$

where $\Omega \equiv (\Theta^*)^{1-\mu}$ sets a reference level of technology transfer. The components in the right-side bracket of condition (1.10) are the factors that affect the requirement on technology transfer. This requirement on Γ becomes relaxed if Country S has a stronger cost disadvantage (smaller $\widetilde{\Psi}$), worse local producers (smaller $\widetilde{\Theta}$), or a wider local market (larger Φ_S). Remember that Country S is a developed (Northern) country. In a North-South setting, Z_S resorts to a Southern Country H for low input costs, the effect of which is through $\widetilde{\Psi}/\Psi$. In comparison, in a North-North setting, Z_S resorts to another Northern Country H for more productive producers, the effect of which is through $\widetilde{\Theta}/\Theta^*$.

The timing of events is as follows. On date 1, Z_H and Z_S propose their respective contracts to X_H and X_H accepts one of the two. The contracts specify who partner with whom and how future revenue will be divided between them. Z_H can only propose to X_H, and has to exit if its proposal is rejected. Z_S will partner with X_S if either its proposal is rejected by X_H, or it does not want to partner with X_H at all.[9] The contracting process is summarized in Figure 1. On date 2, production, sales, and revenue division are carried out according to the contracts.

1.3.2 Equilibrium

The equilibrium characterizes how four parties, X_H, X_S, Z_H, and Z_S, choose their partners given all possible values of Θ. As shown in Figure 1, X_S does not have an option other than Z_S, so the analysis centers on what Z_H and Z_S offer X_H in their respective contracts and how X_H chooses between them. X_H chooses between Z_H and Z_S depending on which one offers a larger profit transfer in its contract; meanwhile, the offers by Z_H and Z_S depend on how each other responds.

Let $\pi_{HH}(\Theta)$ be the maximum joint profit when X_H and Z_H become partners,

$$\pi_{HH}(\Theta) = \max\{\pi_{HH,NON}(\Theta), \pi_{HS}(\Theta)\},$$

and $\pi_{HH}^{X_H}(\Theta)$ be the portion in $\pi_{HH}(\Theta)$ that goes to X_H. The reservation profit for X_H to choose partnership HS is $\pi_{HH}^{X_H}(\Theta)$, while that for Z_S is $\tilde{\pi}$. Thus, partnership HS is chosen by X_H and Z_S if and only if[10]

$$\pi_{HS}(\Theta) - \pi_{HH}^{X_H}(\Theta) - \tilde{\pi} > 0. \tag{1.11}$$

I next investigate when condition (1.11) holds. $\tilde{\pi}$ is known, and $\pi_{HH}^{X_H}(\Theta)$ is unknown but its maximum is $\pi_{HH}(\Theta)$. It is currently unclear whether $\pi_{HH}^{X_H}(\Theta) = \pi_{HH}(\Theta)$; thus, I

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[9] The latter case is equivalent to that Z_S issues an invalid contract to X_H.

[10] The proof of this condition is straightforward. For "if," given the condition satisfied, X_H and Z_S have their reservation profits secured, and thus will accept any division of the extra profit $\pi_{HS}(\Theta) - \pi_{HH}^{X_H}(\Theta) - \tilde{\pi}$. For "only if," to profitably partner with X_H, Z_S must ensure X_H of at least $\pi_{HH}^{X_H}(\Theta)$, leading to $\pi_{HS}(\Theta) - \tilde{\pi} > \pi_{HH}^{X_H}(\Theta)$.

examine instead the condition

$$\pi_{HS}(\Theta) - \pi_{HH}(\Theta) - \tilde{\pi} > 0, \tag{1.12}$$

which is stricter than condition (1.11), and then prove:

Lemma 1 (i) $\pi_{HS}(\Theta) - \pi_{HH}(\Theta) - \tilde{\pi} = 0$ has two solutions $\underline{\Theta}$ and $\overline{\Theta}$: $\underline{\Theta} < \Theta^* < \overline{\Theta}$; (ii) $\pi_{HS}(\Theta) > \pi_{HH}(\Theta) + \tilde{\pi}$ if and only if $\Theta \in (\underline{\Theta}, \overline{\Theta})$.

Lemma 1 presents two thresholds of Θ, $\underline{\Theta}$ and $\overline{\Theta}$, and shows condition (1.12) to hold given $\Theta \in (\underline{\Theta}, \overline{\Theta})$.[11] Its intuition is summarized in Panel (a) of Figure 2, which shows the equilibrium joint-profit schedule from X_H's perspective. Notably, $\tilde{\pi}$, Z_S's reservation profit in cross-border partnership, is essentially a fixed cost from X_H's perspective. Next, I prove

Lemma 2 Conditions (1.11) and (1.12) are equivalent.

The intuition behind Lemma 2 is as follows. When $\Theta \in (\underline{\Theta}, \overline{\Theta})$, Z_H and Z_S compete to get X_H, and Z_S wins by offering a profit of $\pi_{HH}(\Theta)$ to X_H. Z_S matches this offer by keeping no profit for itself; however, by Lemma 1, Z_H can always offer slightly more. In equilibrium, partnership HS is formed, $\pi_{HS}^{Z_H}(\Theta) = 0$, $\pi_{HS}^{X_H}(\Theta) = \pi_{HH}(\Theta)$, and $\pi_{HS}^{Z_S}(\Theta) = \pi_{HS}(\Theta) - \pi_{HH}(\Theta)$. When $\Theta \in [\overline{\Theta}, \infty)$, because of difficulties in cross-border coordination, Z_H can beat Z_S by offering a profit of $\pi_{HS}(\Theta) - \tilde{\pi}$ to X_H. Thus, partnership (HH,B) is formed, $\pi_{HS}^{Z_H}(\Theta) = \pi_{HH,B}(\Theta) - (\pi_{HS}(\Theta) - \tilde{\pi})$, $\pi_{HS}^{X_H}(\Theta) = \pi_{HS}(\Theta) - \tilde{\pi}$, and $\pi_{HS}^{Z_S}(\Theta) = \tilde{\pi}$.

When $\Theta \in (0, \underline{\Theta})$, the analysis is slightly complex. Define Θ_* such that $\pi_{HS}(\Theta_*) - \tilde{\pi} = 0$. With a moderately low $\Theta \in (\Theta_*, \underline{\Theta}]$, X_H finds technology transfer from Z_S attractive,

[11] As a numerical example of $\underline{\Theta}$ and $\overline{\Theta}$, let $\Psi = \tilde{\Psi} = 1$, $\Phi_H = 1$, $\Phi_S = 1.2$, $\Gamma = 1.1$, $\mu = 0.5$, and $\tilde{\pi} = 0.3$; then the two solutions are $\underline{\Theta} = 0.12$ and $\overline{\Theta} = 0.74$.

but its ex-post productivity is not high enough to earn X_H as much profit from cross-border partnership as from within-border partnership for the following reason. If X_H wants to keep Z_S in the partnership, X_H has to pay Z_S the reservation profit $\tilde{\pi}$. After paying $\tilde{\pi}$, X_H earns less than in within-border partnership, because in the partnership with Z_H, X_H has a stronger leverage, thanks to its alternative partner Z_S. Thus, partnership (HH,NON) is formed, $\pi^{Z_H}(\Theta) = \pi_{HH,NON}(\Theta) - (\pi_{HS}(\Theta) - \tilde{\pi})$, $\pi^{X_H}(\Theta) = \pi_{HS}(\Theta) - \tilde{\pi}$, and $\pi^{Z_S}(\Theta) = \tilde{\pi}$. When $\Theta \in (0, \Theta_*]$, X_H cannot afford $\tilde{\pi}$ anyway, so it has no option but to partner with Z_H, leading to partnership (HH,NON). In this partnership, X_H has no leverage such that $\pi^{Z_H}_{HH,NON}(\Theta) = \pi_{HH,NON}(\Theta)$, $\pi^{X_H}_{HH,NON}(\Theta) = 0$, and $\pi^{Z_S}_{HH,NON}(\Theta) = \tilde{\pi}$.

The above discussion has analyzed both profit and partnership schedules for each party. The profit schedules are graphically summarized by Panel (b) of Figure 2. The areas [1], [2], and [3] are the surpluses obtained by Z_S, X_H, and Z_H, respectively. The partnership schedules are summarized by Proposition 1:

Proposition 1 In equilibrium, the partnership schedules are

Ex-ante Productivity	Partnership Type	
$\Theta \leq \underline{\Theta}$	(HH,NON)	SS
$\underline{\Theta} < \Theta < \overline{\Theta}$	HS	HS
$\Theta \geq \overline{\Theta}$	(HH,B)	SS

Three issues are noteworthy here. First, the equilibrium results from interaction between the four parties rather than any one party's unilateral decision. Specifically, the model is not simply X_H sorting itself into one of the three different partnership types, as X_H makes decisions in response to the decisions of the other three parties. The model is also not as simple as Z_S selecting one partner between X_H and X_S, because Z_S's choice depends on how Z_H behaves. It is difficult to say which party of the four is the most active one, because the findings will change if any of the four parties deviates from the equilibrium.

Second, intermediate trade can easily be added to the model. x is a combination of production factors, including capital, labor and intermediates. Suppose that Z_S finishes the intermediates in Country S and ships them to X_H. Then, the c under partnership HS will change relative to $\widetilde{c}$, which nevertheless does no more than change Ψ relative to $\widetilde{\Psi}$ and hence $\underline{\Theta}$ and $\overline{\Theta}$. This also applies to the case in which Z_S provides capital or labor.

Third, transport cost and tariff are absent in the model, but including them does not make a notable difference. For example, with an iceberg transport cost, both π_{HS} and $\pi_{HH,B}$ decline, the former of which declines by a larger magnitude than the latter, because partnership (HH,B) exports only part of its output, but partnership HS exports all of its output. Consequently, $\underline{\Theta}$ rises and $\overline{\Theta}$ declines, discouraging partnership HS relative to partnerships (HH,NON), (HH,B), and SS. This does not change the above findings. A tariff is similar to transport cost in reducing π_{HS} more than $\pi_{HH,B}$, such that trade liberalization encourages partnership HS relative to other partnership types.

1.3.3 Average ex-ante productivity

Up to this point, the model has only four parties involved: X_H, X_S, Z_H, and Z_S. In this four-party setting, X_H has an exogenously determined productivity Θ and the previous discussion focuses on how equilibrium partnership and profit schedules vary by

Θ. Now I consider a world with multiple four-party sets with different Θ.[12] Specifically, Θ is now randomly drawn from a population with cumulative density function $V(\Theta)$, and each Θ is associated with a four-party set. Let θ_0 be the lower bound of ex-ante productivity and $\Theta_0 = \theta_0^{\frac{\alpha}{1-\alpha}}$. Now each four-party set engages in the interaction discussed above. The average ex-ante productivity in the three partnership types are defined as, respectively,

$$\widehat{\Theta}_{HH,NON} \equiv \frac{1}{V(\underline{\Theta}) - V(\Theta_0)} \int_{\Theta_0}^{\underline{\Theta}} \Theta dV(\Theta), \tag{1.13}$$

$$\widehat{\Theta}_{HS} \equiv \frac{1}{V(\overline{\Theta}) - V(\underline{\Theta})} \int_{\underline{\Theta}}^{\overline{\Theta}} \Theta dV(\Theta), \tag{1.14}$$

$$\widehat{\Theta}_{HH,B} \equiv \frac{1}{1 - V(\overline{\Theta})} \int_{\overline{\Theta}}^{\infty} \Theta dV(\Theta). \tag{1.15}$$

It then follows that there is a ranking of average ex-ante productivity among the three partnership types:

Proposition 2 $\widehat{\Theta}_{HH,NON} < \widehat{\Theta}_{HS} < \widehat{\Theta}_{HH,B}$.

1.3.4 Introducing industrial and regional characteristics

The analysis in Section 1.3.3 can be extended by allowing additional parameters of four-party sets to vary. Specifically, the four-party sets can be from different industries, so the effectiveness of technology transfer (γ) varies between industries. In Country H, the producers can be from regions with different qualities of infrastructures and institutions, so the coordination difficulty μ varies between regions within Country H.[13]

[12] The number of X_H-Z_H pairs and the number of X_S-Z_S pairs are implicitly assumed to be equal, so their numbers are equal to the number of four-party sets. If the number of X_H-Z_H pairs is unequal to that of X_S-Z_S pairs, the analysis will entail the interplay among market sizes, free-entry conditions, and entry costs of two countries' local markets. These issues are beyond the scope of this study.

Note that in the previous discussion, both partnership types HS and (HH,B) involve exporting (i.e., to serve Country S). Now I analyze how γ and μ affect the prevalence of one partnership relative to the other in the collection of four-party sets. The shares of the two partnerships that involve exporting, HS and (HH,B), are respectively

$$\sigma_{HS} = \frac{V(\overline{\Theta}) - V(\underline{\Theta})}{1 - V(\underline{\Theta})}, \tag{1.16}$$

$$\sigma_{HH,B} = \frac{1 - V(\overline{\Theta})}{1 - V(\underline{\Theta})}. \tag{1.17}$$

These two equations imply that more exporters will be under partnership HS relative to partnership (HH,B) if (1) the technology transfer from Z_S to X_H becomes more effective (γ increases), or (2) the coordination between Z_S and X_H becomes easier because of the higher quality of infrastructures and institutions in the region where X_H is located (μ increases).

Next, I assume $V(\Theta) = 1 - (\Theta_0/\Theta)^{\zeta}$, $\zeta > 0$; i.e., Θ follows a Pareto distribution.[14] Thus, $\sigma_{HS} = 1 - \left(\underline{\Theta}/\overline{\Theta}\right)^{\zeta}$, $\sigma_{HH,B} = \left(\underline{\Theta}/\overline{\Theta}\right)^{\zeta}$. It follows that more exporters would be under partnership HS relative to partnership (HH,B) if the dispersion of Θ becomes smaller (ζ increases). To summarize,[15] ,[16]

Proposition 3 Among exporters, cross-border partnership becomes more prevalent than

[13] Coordination can also be affected by industrial characteristics, which would not affect Proposition 3. The reason is as follows. Let $\mu = \overline{\mu} + \mu_{in}$, where $\overline{\mu}$ and μ_{in} are region- and industry-specific, respectively. Then, $g = (\gamma\theta)^{\mu} = (\gamma\theta)^{\overline{\mu}+\mu_{in}} = \gamma^{\overline{\mu}}\gamma^{\mu_{in}}\theta^{\overline{\mu}+\mu_{in}}$, where $\gamma^{\overline{\mu}}$ is industry-region specific and $\gamma^{\mu_{in}}$ is industry-specific. Parts (i) and (ii) of Proposition 3 can be proved as before. Part (iii) of Proposition 3 does not involve γ or μ, so it is unaffected.

[14] For analyses of the Pareto distribution, see Axtell (2001) and Helpman, Melitz, and Yeaple (2004) for empirical evidence, and Gabaix (2009) and Rossi-Hansberg and Wright (2007) for theoretical discussions.

[15] $\sigma_{k'}$ is the share of exporters in partnership type $k' \in \{HS, (HH,B)\}$. If the total number of four-party sets is M, the number of type k' exporters is $\sigma_{k'}M$. The number ratio of HS exporters to (HH,B) exporters is thus $\sigma_{HS}M/\sigma_{HH,B}M = \sigma_{HS}/\sigma_{HH,B}$. See footnote 12 for the discussion on the number of four-party sets.

[16] Note that only part (iii) of Proposition 3 relies on the assumption of a Pareto distribution. I will revisit this assumption in the next chapter.

within-border partnership, given more transferable technology, less productivity dispersion, or easier cross-border coordination. Formally, $d(\frac{\sigma_{HS}}{\sigma_{HH,B}})/d\gamma > 0$; (ii) $d(\frac{\sigma_{HS}}{\sigma_{HH,B}})/d\mu > 0$; (iii) $d(\frac{\sigma_{HS}}{\sigma_{HH,B}})/d\zeta > 0$.

Proposition 3 shows how relative prevalence of partnership types depends on industrial and regional characteristics. Notably, under partnership types HS and (HH,B), the products are both "Made in Country H;" but the product designs are from Country S and Country H, respectively, as designs are provided by headquarters.

1.3.5 Organizational form

The previous discussion does not consider the organizational form of cross-border partnership. Now I assume that Z_S also specifies the organizational form $m \in \{O, I\}$ in its proposed contract, where I and O denote vertical integration and arm's length, respectively. Compared with arm's length, vertical integration facilitates technology transfer and coordination, but incurs a higher fixed cost: $\Gamma_I > \Gamma_O$, $\mu_I > \mu_O$, $f_I > f_O = 0$.[17] Then, the model can be resolved and generates the following findings:

Proposition 4 Let $\underline{\Theta}_m$ and $\overline{\Theta}_m$ be the new productivity thresholds among partnership types. Then, (i) $\underline{\Theta}_O = \underline{\Theta} < \underline{\Theta}_I < \overline{\Theta}_O = \overline{\Theta} < \overline{\Theta}_I$, (ii) the thresholds between partnership types (HH,NON), HS, and (HH,B) are $\underline{\Theta}$ and $\overline{\Theta}_I$; (iii) if joint profits satisfy

$$\pi_{HS,I}(\overline{\Theta}_I) > \pi_{HS,O}(\overline{\Theta}_I) \tag{1.18}$$

$$\pi_{HS,I}(\underline{\Theta}) < \pi_{HS,O}(\underline{\Theta}),$$

there exists Θ_I such that $\underline{\Theta} < \Theta_I < \overline{\Theta}_I$ and

[17] Notably, the previous analysis in this chapter focuses the arm's length case.

$$(k,m) = \begin{cases} (HS,O) & \text{if} \quad \underline{\Theta} < \Theta < \Theta_I \\ (HS,I) & \text{if} \quad \Theta_I \leq \Theta < \overline{\Theta}_I; \end{cases} \tag{1.19}$$

(iv) Define

$$\widehat{\Theta}_{HS,O} \equiv \frac{1}{V(\Theta_I) - V(\underline{\Theta})} \int_{\underline{\Theta}}^{\Theta_I} \Theta dV(\Theta), \tag{1.20}$$

$$\widehat{\Theta}_{HS,I} \equiv \frac{1}{V(\overline{\Theta}_I) - V(\Theta_I)} \int_{\Theta_I}^{\overline{\Theta}_I} \Theta dV(\Theta); \tag{1.21}$$

then,

$$\widehat{\Theta}_{HS,O} < \widehat{\Theta}_{HS,I}.$$

The intuition behind Proposition 4 is graphically illustrated by Figure 3. Notice that conditions (1.18) are used to ensure $\Theta_I \in (\underline{\Theta}, \overline{\Theta}_I)$. Violating them does not alter the analysis, but it removes one of the two organizational forms from the equilibrium.

1.4 Robustness: served market and functional form

This chapter focuses on how host-country producers with different levels of productivity serve Country S in different partnership types. To sharpen the analysis, the model has so far assumed cross-border partnership to serve only Country S. I now show that the previous results hold if cross-border partnership instead serves both countries. In that case, profit function in partnership HS becomes

$$\pi_{HS}(\Theta) = \Psi(\Phi_S + \Phi_H)\Gamma\Theta^{\mu}. \tag{1.22}$$

Then the necessary condition (1.10) for the presence of cross-border partnership in equilibrium becomes

$$\Gamma > \left[(1-\Delta)\left(\frac{\widetilde{\Psi}}{\Psi}\right)\left(\frac{\widetilde{\Theta}}{\Theta^*}\right) + \Delta\right]\Omega. \tag{1.23}$$

where $\Delta = \Phi_H/(\Phi_H + \Phi_S)$, which is smaller than the Φ_H/Φ_S in condition (1.10), namely a weak version of relative market size.

Returning to Figure 2, the only difference that this additional served market introduces is a far rightward intersection between π_{HS} and $\pi_{HH,B}$. Propositions 1 and 2 still hold, as the three sections in the productivity spectrum have the same relative location as before. So do Propositions 3 and 4, as they are unrelated to the market(s) that cross-border partnership serves. This analysis can be generalized by using additional markets of irregular sizes for cross-border partnership. Unlike within-border partnership in the host country, cross-border partnership can serve a third market, which is referred to as export-platform FDI in the literature (Ekholm, Forslid, and Markusen, 2007).[18] This third-market advantage results from the fact that Z_S may have marketing and sales channels that are unavailable to Z_H. Its effect is technically the same as Δ in condition (1.23).

The case in which cross-border production serves two markets is useful for showing how functional form affects the previous findings.[19] I next show that using a different functional form leads to the same result. The functional form in equation (1.4) neatly presents the fact that γ is constrained by difficult cross-border coordination $\mu \in (0,1)$, but γ can also be constrained by factors other than μ. For instance, γ can be constrained by itself–Z_S "has little to teach" if the producer is sufficiently productive–then γ reaches its limit if θ is sufficiently high. Formally, $d\gamma(\theta)/d\theta > 0, d^2\gamma(\theta)/d\theta^2 < 0$, so $\gamma\theta$ approaches θ

[18] As discussed in Section 1.3.5, the headquarter and producer in cross-border production can also operate at arm's length in this study; this practice is export-platform **subcontracting**.

[19] This discussion on alternative functional form also applies to the case in which cross-border partnership serves only Country S (the benchmark model) or serves a third market (export-platform FDI/subcontracting). The use of the two-market setting provides a clearer graphical presentation. As shown in Figure 4, the alternative functional form translates into a self-explanatory slope change.

as θ rises.

Now, let cross-border partnership use the production function

$$y_{HS} = \mu\gamma(\theta)\theta x_{HS}, \mu \in (0,1), \tag{1.24}$$

and within-border partnership in Country H uses production function (1.2) as before. Define $\pi'_{HH,B}$ as the profit from within-border partnership with cross-border coordination, which is a hypothetical case to facilitate the analysis. Formally, this hypothetical within-border partnership employs

$$y'_{SS} = \mu\theta x'_{SS}. \tag{1.25}$$

As shown in Figure 4, the productivity advantage of cross-border partnership attenuates as Θ rises, so π_{HS} eventually parallels $\pi'_{HH,B}$. As previously shown, X_H with mid-range Θ still chooses partnership HS, while high and low Θ lead to partnerships (HH,B) and (HH,NON), respectively. Therefore, Propositions 1–4 can be similarly proved as before.

After showing theoretical robustness, I present the empirical evidence of Propositions 1–4 in the next chapter.

Chapter 2

The Choice of Partner: Empirical Evidence

2.1 Introduction

The findings in Chapter 1 are evaluated using firm-level data from China. China is arguably the ideal case for examining cross-border partnership since it is by now the largest exporting country in the world and the largest host country for foreign direct investment in the developing world. The model generates three testable predictions. (1) On average, Chinese producers that engage in within-border partnership (i.e., partnering with a Chinese headquarter) and serve only China have low productivity, those involved in cross-border partnership (i.e., partnering with an overseas headquarter) have mid-range productivity, and those involved in within-border partnership and serving both China and overseas markets have high productivity. (2) Among all exporters in China, cross-border partnership is more prevalent than within-border partnership in the industries with more transferable technology and less productivity dispersion. Cross-border partnership is also more prevalent in the regions that have higher qualities of infrastructures and institutions, because good infrastructures and institutions facilitate cross-border coordination. Notably, my focus is the effect of infrastructures and institutions on the composition of exporters, while the existing literature emphasizes the effect on aggregated trade flows. See Bougheas, Demetriades, and Morgenroth (1999), Levchenko (2007), Nunn (2007), and Nunn and Trefler (2008). (3) Among Chinese producers in cross-border partnership, those with relatively high productivity are vertically integrated with their headquarters, while those with relatively low productivity operate at arm's length with their headquarters.

The first prediction finds strong support from a simple regression of firm productivity on partnership types. A number of factors are considered that could potentially confound the result. The first is local tax policies of China–as those of other developing countries–favor cross-border over within-border partnership. I examine both ad-valorem as well as lump-sum tax favors, showing that my results are robust to incorporating taxation effects into the analysis (see Section 3.2). The second is causes other than initial productivity. The model centers on initial productivity, but the estimated productivity differences may also result from technology transfer as well as heterogeneity in products and headquarters across partnership types.

To isolate the effect of producers' initial productivity, I examine the firms that undertook within-border partnership and sold their products only in China, but later switched to either cross-border partnership or within-border partnership serving both China and abroad. The results show that **before switching** the producers that eventually switched to within-border partnership serving both Chinese and overseas markets had high productivity, those that ultimately switched to cross-border partnership had mid-range productivity, and those that never switched at all had low productivity. These results directly support the idea that initial productivity determines the interaction between headquarters and producers.

I go on to test the second and third predictions of the model, investigating the impact of industrial and regional characteristics on relative prevalence of different partnership types in exporters, as well as the effect of productivity on the organizational form that is chosen. The empirical findings are in line with the predictions. In particular, among firms undertaking cross-border partnership, those that switched from arm's length to vertical integration were more productive before switching than those that remained at arm's length, again attesting to the effect of initial productivity.

2.2 Data

The primary data source for my empirical work is the **Annual Surveys of Industrial Production** (ASIP) from 2000 through 2003 conducted by the National Bureau of Statistics of China. A number of papers have recently used this data for other purposes, including Hsieh and Klenow (2009), Lu, Lu, and Tao (2009), Park, Yang, Shi, and Jiang (2009), and Qian (2008). These annual surveys collected detailed information on firms that were either state- or non-state owned with annual sales of 5,000,000 Yuan or more, including sales revenue, exported value, capital, employment, and wage. The industry section of **China Statistical Yearbooks** was compiled using these surveys. In the covered years, the exchange rate was approximately $1=8.27 Yuan. So 5,000,000 Yuan were equivalent to about $600,000.

Firm-level information on ownership (domestic or overseas) and sales destination (domestic or overseas) reported by the ASIP, as summarized in Table 1**,** is used to identify the partnership types and organizational forms specified in the theoretical model. Recall that there are three partnership types for host-country producers: (HH,NON), HS, and (HH,B). The two partnership types of within-border partnership, (HH,NON) and (HH,B), correspond to domestically owned firms that serve only the Chinese market and both Chinese and overseas markets, respectively. The partnership type of cross-border partnership, HS, refers to the firms that serve only the overseas market; they can be either domestically owned or foreign-owned,[1] depending on their organizational form: arm's length (HS,O) or vertical integration (HS,I).

Table 2 reports the share of each partnership type in total value of exports and total number of exporters during the years 2000-2003. Cross-border partnership, or HS, accounts for roughly 40% in total exported value and 35% in total number of exporters. Under partnership HS, the ratio between ownerships (domestic to overseas) is about 2:3.

2.3 Relative productivity

Propositions 2–4 are directly testable and I start with Proposition 2. I first specify a simple regression

$$\ln TFP_{djrt} = \omega + \kappa' TYPE_d + \iota' C_{drt} + \nu_j + \nu_t + \epsilon_{djrt}, \tag{2.1}$$

and include in the sample only those firms with invariant partnership types over time. This specification is convenient in estimating productivity differences among partnership types.[2] The dependent variable is total factor productivity (TFP) calculated using Levinsohn-Petrin (2003) estimates. TFP is the output not explained by inputs used in

[1] According to **The Law of the People's Republic of China on Foreign-funded Enterprises**, overseas-owned firms refer to "those enterprises established in China by foreign investors, exclusively with their own capital, in accordance with relevant Chinese laws."

[2] Regressions in the other way around (i.e., partnership types on TFP) are reported in Appendix B and show the same results.

production. Its value relies on the estimated coefficients of inputs in the production function. OLS estimates of the input coefficients are potentially biased by unobservables. To address the bias, the Levinsohn and Petrin (2003) method uses intermediate inputs to proxy for the unobservables.

Indices d, j, r, and t represent firm, industry, region, and year, respectively. $TYPE_d$ is a vector of dummy variables that indicates firm d's partnership type. Firms under (HH,NON) serve as the reference group. $TYPE_d = [HS_d, HHB_d]'$, $HHB_d = 1$ if the firm is under (HH,B), $HS_d = 1$ if the firm is under either (HS,O) or (HS,I), and κ_{HS} and κ_{HHB} are their respective coefficients. C_{drt} is a set of firm/region characteristics in year t. An industry is defined by a four-digit industry code. ν_j and ν_t are industry and year fixed effects, respectively. ϵ_{djrt} is a classic error term.

Table 3 shows $\widehat{\kappa}_{HHB} > \widehat{\kappa}_{HS} > 0$, supporting the prediction of Proposition 2. The difference between $\widehat{\kappa}_{HS}$ and $\widehat{\kappa}_{HHB}$ is statistically significant at 1% level in all columns. Column (1) is the baseline regression without control variables. Column (2) is similar to (1) but controls for profit margin, capital intensity, and regional population. The profit margin, defined as pre-tax profit over sales in the literature (Phillips, 1995), purges possible market power from the estimated productivity; capital intensity and regional population as control variables reduce noises caused by industry composition and local market size.[3] Columns (1)–(2) have included fixed effects, while column (3) includes random effects.

Next I discuss whether various confounding factors influence these results. First, I examine whether the results are affected by taxation effects. Developing countries such

[3] As in Antras (2003), capital intensity is measured using the ratio of capital stock to total employment.

as China usually have local tax policies that favor cross-border partnership. I consider ad-valorem and lump-sum tax favors, respectively, which affect the empirical results in different ways. Ad-valorem tax favors provide producers with the highest productivity the incentives to choose cross-border partnership. In absence of tax incentives, these producers would have chosen within-border partnership. This effect is harmless in this study because it strengthens rather than weakens the previous finding. Remember that Table 3 documents a productivity premium of firms in within-border partnership serving both domestic and overseas markets relative to those undertaking cross-border partnership. In effect, the ad-valorem tax favors reduce this estimated productivity premium, such that the real premium is larger than estimated.

Unlike ad-valorem tax favors, lump-sum tax favors may affect the empirical results through contaminating TFP. TFP is the output not explained by inputs used in production, and tax payment is not an input of production; thus, reduced tax payment may present itself as an increase in TFP. To address this, the regression is rerun with tax payment included as shown in column (4) of Table 3. Notably, the coefficients of HS and HHB are very close to those in columns (1)–(3), suggesting that the lump-sum tax favors are not a significant issue. In China, there are export-promotion zones (EPZs) and free-trade zones (FTZs) where exports are promoted by multiple policy instruments that are not applicable to the rest of China, such as lower taxes, eliminated quotas, or bureaucratic requirements.[4] Firms are accordingly divided into two subsamples according to whether a firm is inside a four-digit administrative division with a EPZ/FTZ. Columns (5) and (6) replicate column (4) using the two subsamples and show the same

[4] Four-digit level administractive division in China refers to prefecture-level cities. A perfecture is typically an urban center with surrounding rural areas that are much larger than the urban center.

findings. The coefficients of HS and HHB are slightly different from those in other columns, indicating that FTZs and EPZs may have different industry composition from other regions.

Second, I determine whether the results are affected by industry composition. Certain partnership types may be concentrated in an industry for some reason, and thus the results in Table 3 are possibly driven by industry composition. To address this, columns (1)–(6) all include industry effects, either fixed or random. In addition, I specifically look into two industries, apparel and electronics, which have the largest trade surplus in all industries and are meanwhile of opposite levels of sophistication. Columns (7)–(8) present the regressions respectively using the two subsamples, the results of which point to the same conclusion as those in columns (1)–(6).

Third, I address whether the results are affected by outliers**.** Table 4 reports the results from quantile regressions with similar specifications as in Table 3, which show that the results in Table 3 are robust with respect to extreme values. In addition, I calculated the differences between the coefficients of the two dummy variables, and found that the productivity premium of partnership (HH,B) relative to partnership HS becomes larger at higher quantiles, suggesting that the productivity distribution is skewed to the right. In other words, the larger is the productivity dispersion, the more firms with high productivity fall in partnership (HH,B), supporting the assumption of Pareto-distributed productivity discussed earlier.

Fourth, I evaluate whether the results are specific to the parametric estimation approach. Least-squares regression and quantile regression fit linear conditional mean expectation and conditional quantile expectation, respectively. Notice that the foundation of Proposition 2, Proposition 1, argues that the productivity ranking among the three partnership types holds in terms of distribution rather than expectation. A non-parametric test on Proposition 2 will be discussed later, together with a nonparametric test of Proposition 4(iv).

Fifth, I investigate whether the estimated ranking of productivity indeed reflects the ranking of ex-ante productivity. Tables 3 and 4 establish productivity differences between the three partnership types, but cannot pinpoint the ultimate sources of the differences. Recall that the theoretical model centers on ex-ante productivity. Ex-ante productivity is not directly estimable, which means that the estimated productivity differences may not result from differences in ex-ante productivity but other differences between the three partnership types. For instance, cross-border partnership produces intermediates, whereas within-border partnership produces final goods; in that case, measured productivity is not comparable among partnership types.

To address this concern, I examine the firms that engage in cross-border partnership and serve only the Chinese market (i.e., (HH,NON) in the model) in year t. They have three options in year $t+1$: stay under the same partnership, switch to cross-border partnership (i.e., HS in the model) or switch to within-border partnership serving both Chinese and overseas markets (i.e., (HH,B) in the model). Their production activities, even if not comparable after switching (year $t+1$), were comparable before the switching (year t), because they were then undertaking the same production activity under the same partnership. In terms of the theory, in an ideal setting, researchers study firms on date 1 (interaction and contracting). In practice, however, date 1 finishes quickly and date 2 (production) immediately follows, such that what statistical agencies observe is only date 2. This study's approach is to examine the change in partnership type between one date 2 and another date 2. Specifically, if a firm in partnership type (HH,NON) in year t switches to partnership HS or (HH,B) in year $t+1$, there must be a new date 1 (another interaction and contracting) that takes place between the two consecutive years. Date 1 is not documented in the data, but it is reflected in the production activity of year $t+1$.

Formally, each observation (a firm-year pair) under partnership (HH,NON) is assigned two dummy variables:

$$PRE\text{-}HS_{dt} = \begin{cases} 1, & \text{if } HS_{dt+1} = 1, \\ 0, & \text{otherwise,} \end{cases}$$

and

$$PRE\text{-}HHB_{dt} = \begin{cases} 1, & \text{if } HHB_{dt+1} = 1, \\ 0, & \text{otherwise,} \end{cases}$$

and TFP is regressed on $PRE\text{-}HS$ and $PRE\text{-}HHB$ along with control variables:

$$\ln TFP_{djrt} = \tau + \chi_1 PRE\text{-}HS_{dt} + \chi_2 PRE\text{-}HHB_{dt} + \iota' C_{drt} + \varrho_j + \rho_t + \epsilon_{djrt}. \tag{2.2}$$

The reference group is now firms that remain under partnership (HH,NON) in year $t+1$. Then, $\widehat{\chi}_2 > \widehat{\chi}_1 > 0$ if the difference in ex-ante productivity is present.

Table 5 establishes the effect of ex-ante productivity. First, switchers were on average more productive than non-switchers before switching; second, firms that eventually switched to (HH,B) were on average more productive than those that eventually switched to HS (the difference is statistically significant at 1% level). Notably, the average productivity difference between HS and (HH,NON) in Table 5 is approximately one fourth of that in Table 3, and the average productivity difference between (HH,B)

and HS in Table 5 is about half of that in Table 3. That is, as expected, ex-ante productivity explains only part of the differences in measured productivity among the three partnership types.

2.4 Prevalence of exporters across partnership types

Proposition 3 says that the share of exporters in partnership HS relative to (HH,B) rises if technology transfer becomes more effective (γ increases), coordination difficulty lowers (μ increases), or dispersion of productivity diminishes (ζ increases). γ and ζ are industrial characteristics. Technology complexity measured by R&D intensity reduces the effectiveness of technology transfer.[5] A dummy variable $HITECH$ is constructed to proxy for γ, which equals 1 if a given firm is from a high-technology industry and 0 otherwise.[6] ζ reflects the productivity similarity among firms within an industry, from all firms being almost identical to all firms ranked clearly as a spectrum, and it is inversely measured by the standard deviation of TFP, denoted by $DISP$.

Unlike γ and ζ, μ is primarily affected by local infrastructures and institutions. Coordination would not be an issue if the host country had infrastructures and institutions identical to those in the source country. High-quality local infrastructures facilitate cross-border coordination between Chinese producers and their source-country headquarters. Meanwhile, good local institutions, including the protection of intellec-

[5] Using R&D intensity as a measure of technology complexity follows the literature; e.g., Carluccio and Fally (2008), and Keller and Yeaple (2010).

[6] The "classification of manufacturing industries based on technology" published in **OECD Science, Technology and Industry Scoreboard 2005** (p.182) is used to distinguish high-technology industries from low-technology ones. High-technology industries in the text refer to high- and medium-high technology industries in the classification, which include (1) aircraft and spacecraft; (2) chemicals, including pharmaceuticals; (3) office, accounting and computing machinery; (4) radio, TV, and communications equipment; (5) medical, precision, and optical instruments; (6) electronic machinery and apparatus; (7) motor vehicles, trailers, and semi-trailers; (8) railroad equipment and transport equipment; and (9) machinery and equipment, n.e.c.

tual properties and availability of legal and accounting services, are also important in providing a business-friendly environment for cross-border partnership.

This study uses the marketization index published by the **National Economic Research Institute of the China Reform Foundation** as a proxy for local infrastitutions across regions in China. Compiled for each province, this index, denoted by $LOCAL$, quantitatively evaluates (1) the relationship between local government and market (e.g., tax burden and local government size), (2) the development of the local private sector (e.g., its size relative to other sectors), (3) the efficiency of local product markets (e.g., protectionism in favor of local firms), (4) the efficiency of local factor markets (e.g., financial service and labor mobility), and (5) the local legal environment and the availability of market intermediaries (e.g., intellectual property-protection, as well as the number of accountants and lawyers in the population).[7]

The data are then aggregated to the industry-province-year level, and Proposition 3 is tested with the regression:

$$\left(\frac{\sigma_{HS}}{\sigma_{HH,B}}\right)_{jrt} = \varphi_0 + \varphi_1 HITECH_j + \varphi_2 DISP_{jt} + \varphi_3 LOCAL_{rt} + \vartheta' M_{jrt} + u_{jrt}, \tag{2.3}$$

where $\sigma_{HS}/\sigma_{HH,B}$ is the number ratio of exporters in cross-border partnership relative to within-border partnership, and M_{jrt} is a set of industry- and province-level characteristics in year t. Now j refers to a two-digit industry because $HITECH$ is only available at the two-digit level; furthermore, the dependent variable has much fewer zeros at the two-digit level than at the four-digit level. A possible concern is that $\sigma_{HS}/\sigma_{HH,B}$ is contaminated by industry composition. For instance, some industries are more labor-

[7] The **Marketization Index Report 2006** reports cross-province marketization indices for years 2001-2005, while the ASIP data cover the years 2000-2003, so I use the data for the overlapping years 2001-2003 for this analysis.

intensive than others; meanwhile, labor-intensive production tends to be located in China by developed-country headquarters because of low labor costs in China. To address this, capital intensity is included as a control variable. Provincial population is included as well to prevent $\sigma_{HS}/\sigma_{HH,B}$ from being driven by the size of local economy.

The regression results are reported in Table 6. Column (1) uses the full sample and presents the OLS estimates, which are consistent with the theoretical prediction: $\widehat{\varphi}_1 < 0$, $\widehat{\varphi}_2 < 0$, $\widehat{\varphi}_3 > 0$.[8] All observations with zero-value dependent variables are dropped from the sample in column (2), and Tobit estimation is used instead in column (3), both of which point to the same findings. Lastly, the dependent variable has three dimensions: industry, province and year; therefore, there are potential province-industry autocorrelation within a year, province-year correlation within an industry, and industry-year correlation within a province. In column (4), OLS is used with the three-way clustering proposed by Cameron, Gelbach, and Miller (2008), which simultaneously controls for clustering in all three dimensions. Column (4) shows that the findings from columns (1)–(3) still hold.

2.5 Organizational form

Proposition 4 predicts that in cross-border partnership, producers at arm's length have lower ex-ante productivity than those in vertical integration. Using samples of firms under partnership HS, Table 7 regresses TFP on a dummy variable that equals 1 for vertical integration, and shows that vertical integration is associated with a higher

[8] It should be noted that $DISP$ is the disperson of ex-post productivity rather than that of ex-ante productivity. This is not a significant concern for the following reason. $g = (\gamma\theta)^{\mu}$, or $\ln g = \mu \ln\gamma + \mu \ln\theta$. Notice that γ and μ are included in the regression; what $\widehat{\varphi}_2$ captures is the effect of ex-ante productivity.

average productivity than arm's length. Column (1) includes no control variables, while column (2) includes profit margin, capital intensity, and regional population with the same rationale as in column (2) of Table 3. Both columns (1) and (2) use fixed effects while column (3) uses random effects. Columns (4)–(6) consider tax payments and EPZ/FTZ as their counterparts in Table 3. In columns (7)–(8), the regression is rerun with the subsamples of firms in apparel and electronics. All these specifications lead to the same finding.

Similar to Table 3, Table 7 may capture differences between organizational forms other than ex-ante productivity. For example, the estimated productivity differences could result from technology transfer between organizational forms rather than ex-ante productivity. It should be noted that my theoretical model does predict more effective technology transfer in vertical integration than at arm's length; however, this effect ultimately works through the influence of ex-ante productivity. Also, the estimated productivity difference in Table 7 may also result from the heterogeneity in source-country headquarters.

To address the above concerns, Table 8 follows a similar specification as Table 5, which focuses on the firms that were in partnership (HS, O) in year t but switched to partnership (HS, I) in year $t+1$; in the latter case, the dummy variable $PRE\text{-}I$ equals 1. The results show that the firms that eventually switched to partnership (HS, I) were on average more productive than nonswitchers before integration, which cannot be explained by the differences in technology transfer or source-country headquarters. This lends strong support to the effect of ex-ante productivity on the choice of organizational form. Quantitatively, ex-ante productivity explains about 70% of the productivity premium of vertical integration relative to arm's length.[9]

2.6 Nonparametric results

Proposition 1 rationalizes the relationship between ex-ante productivity and partnership type, and Proposition 2 provides a simple version of Proposition 1 that is easy to test parametrically. Similarly, Proposition 4(iii) demonstrates the relationship between ex-ante productivity and organizational form, and Proposition 4(iv) provides a simple version for parametrical testing. It should be noted that Propositions 1 and 4(iii) hold for any productivity level across the spectrum rather than only in terms of parameters (e.g., mean and median). In order to test these propositions without resorting to parameters, a relative distribution function is employed in Figure 5 to compare the distribution of productivity across partnership types and organizational forms.

2.7 Conclusions and policy implication

This section concludes Chapters 1 and 2 and discusses policy implication of this study. This study provides a theory of the interaction between headquarters and producers in a world of globalized production. Specifically, it addresses what types of foreign producers are serving developed countries. There are two types of these foreign producers. The first type has mid-range productivity and works with developed-country headquarters, while the second type has high productivity and partners with local headquarters. The former does not serve its local market, while the latter serves both local and developed-country markets.

[9] The coefficients of $PRE\text{-}I$ in Table 8 are not as significant as 1% because of the small number of switchers in the data (58 out of 7358), so caution is needed in interpretating their magnitudes.

The theory also predicts that cross-border partnership is more prevalent in the industries with more transferable technologies and less heterogeneous producers, as well as in the regions with higher quality infrastructures and institutions, and that in cross-border partnership, foreign-country producers with relatively high productivity are vertically integrated with their headquarters, while those with relatively low productivity operate at arm's length with their headquarters. These predictions are supported by firm-level evidence from China.

There are at least two important directions for future research. The first is to examine the dynamic aspects of the model. For instance, an advanced technology in the developed country, once transferred to a foreign producer, may carry over to that producer's future partnership with its local headquarter. This provides the foreign producer and the developed-country headquarter incentive and disincentive, respectively, to undertake cross-border partnership. The second is to consider general-equilibrium effects in the model. For instance, technology transfer may drive up factor prices in the foreign country, which forces the least productive foreign producers to exit; therefore, the foreign country gains from improved aggregate productivity.

The direct policy implication is on the quality problem of outsourcing products. It is often reported that products made in developing countries and sold in developed countries have low quality.[10] My study suggests the importance of investigating the partnership under which low-quality products are made. Specifically, my study could partially explain the quality problems associated with cross-border production. Suppose that quality and productivity are positively correlated; that is, low-productivity

[10] For instance, The Economist, "Poorly Made," May 14th 2009.

producers make low-quality products. The findings of this study indicate that medium-productivity producers in China work with the US multinationals. So, they supply medium-quality products to the US. Their medium quality, by the US standard, is sometimes low quality. In that case, incentives should be given to high-productivity producers in developing countries such that they supply high-quality products to the US. By the US standard, their products may have just medium quality, but still better than low quality products.

Chapter 3

The Choice of Technology

3.1 Introduction

In developing economies, there is an increasing number of subsidiaries built by multinational corporations (MNCs) from both developed and emerging economies. It remains unclear whether productivity of factors in multinational subsidiaries varies by parent location. On the one hand, skilled labor in developed-economy subsidiaries is likely to be more productive because innovations in developed economies favor skilled labor;[1] on the other hand, adopting skilled-biased technologies is more costly in unskill-abundant developing economies, which makes these technologies less attractive.[2]

The foreign-direct-investment (FDI) inflow of China is the largest in the developing world, second only to the U.S. worldwide. Using firm-level data from the Chinese electronics industry, this chapter finds that the productivity of skilled labor in developed-economy subsidiaries is significantly higher than that in the emerging-economy subsidiaries, whereas the productivity of unskilled labor does not vary by parent location. We interpret this as a result of the skill-biased technological change in developed-economy technologies; it is too costly for MNCs to innovate unskill-biased technologies

[1] Innovations are predominantly carried out in developed economies. The G-7 countries account for more than 90% of the world's R&D spending (Keller, 2001).

[2] See Hornstein, Krusell, and Violante (2005) and Voilante (2007) for literature reviews.

to customize their production facilities in developing economies.

This study makes three contributions. First, it addresses whether skill bias of technologies is inherent in developed-country technologies. To date, the reason for this skill bias remains unclear. There are two primary explanations: (1) technological change is inherently skill biased (see, e.g., Autor, Katz, and Krueger (1998), Greenwood and Yorukoglu (1997), and Griliches (1969)), and (2) skilled bias is caused by the change in economic fundamentals of OECD countries such as increasing supply of skilled labor.[3] This study suggests that skill bias is more significant as an inherent feature of developed-country technologies, because otherwise unskilled labor would show a higher productivity in developed-country subsidiaries in respond to local unskilled labor abundance.

Second, this study explains why there exists mismatch between developed-country technologies and developing-country labor forces. Anecdotal evidence shows that mismatch is significant; for instance,[4]

> [i]n a recent survey, 600 chief executives of multinational companies with businesses across Asia said a shortage of qualified staff ranked as their biggest concern in China and South-East Asia...Across almost every industry and sector it was the same.

My study suggests that the skill bias in developed-country technologies is inherent and therefore the mismatch is unavoidable. This rationalizes the fact that developed-country MNCs move skill-demanding production to unskill-abundant Asia.

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[3] See, e.g., Acemoglu (1998, 2002) and Kiley (1999)

[4] See **The Economist**, 08/16/2007. Acemoglu and Zilibotti (2001) provide indirect evidence of this mismatch with a cross-country empirical study.

Finally, this study points to where technical spillovers through foreign direct investment (FDI) might be found. FDI spillovers measured by total factor productivity (TFP) are found in developped countries (e.g., Keller and Yeaple, 2009; Haskel, Pereira, and Slaughter, 2007), but whether it exists in developing countries is unclear (Aitken and Harrison, 1999; Haddad and Harrison, 1993). My study implies that future studies should look into the productivity of skilled labor for the effect of FDI spillovers.

This chapter proceeds as follows. Section 3.2 discusses empirical specification, data set, and identification strategies. Section 3.3 presents our main results, and Section 3.4 concludes.

3.2 Specification and data

My specification is a micro-level variant of Caselli and Coleman (2006), which is innovative in that the absolute productivity of each type of labor can be directly examined. Consider a function with constant elasticity of substitution

$$Y = K^{\alpha}[(A_u L_u)^{\sigma} + (A_s L_s)^{\sigma}]^{(1-\alpha)/\sigma}, \tag{3.1}$$

where Y is value-added, K is capital proxied by fixed assets, L_u (L_s) is the employment of unskilled (skilled) labor and A_u (A_s) is its productivity. The elasticity of substitution between skilled and unskilled labor is $1/(1-\sigma)$. α and σ are assumed to be the same across countries, while A_u and A_s are hypothesized to vary across countries, namely developed and emerging economies in this context.[5] In brief, the purpose of this study is to back out A_s, A_u, and A_s/A_u, and compare them across multinational subsidiaries

[5] This follows the practice in the literature on skill-biased technical change; see Caselli and Coleman (2006, footnote 9, p.502).

from different parent sources. Wage share of labor can proxy for $(1-\alpha)$. I need to pinpoint σ and then use the variation in the data on L_s and L_u to obtain the variation in A_s and A_u.

To determine σ, I employ the following procedure. The first-order condition implies that

$$\frac{W_s}{W_u} = (\frac{A_s}{A_u})^{\sigma}(\frac{L_s}{L_u})^{\sigma-1}, \tag{3.2}$$

or

$$\ln\frac{L_s}{L_u} = \frac{\sigma}{1-\sigma}\ln\frac{A_s}{A_u} - \frac{1}{1-\sigma}\ln\frac{W_s}{W_u}. \tag{3.3}$$

I construct a dummy variable DE, which equals 1 if a given subsidiary is from developed economies, and 0 if from emerging economies. In a regression of $\ln L_s/L_u$ on DE and $\ln(W_s/W_u)$,

$$\left(\ln\frac{L_s}{L_u}\right)_{fc} = \phi + \beta \cdot DE_f - \gamma\left(\ln\frac{W_s}{W_u}\right)_c + \zeta' Z_c + \epsilon_{fc}, \tag{3.4}$$

$\widehat{\gamma}$ estimates the $1/(1-\sigma)$ in equation (3.3) and thus allows backing out σ. f and c are firm and city indices, respectively. Z_c is a vector of other city characteristics. The endogeneity of $\ln(W_s/W_u)$ is not a significant concern for two reasons: first, multinational subsidiaries account for less than 10% of the total number of firms in this study, and thus it is unlikely that they drive the equilibrium wages in local labor markets; second, city-level wages have been lagged by one year.

With the obtained σ, I separately impute $A_{s,f}$ and $A_{u,f}$, namely firm-level productivity of skilled and unskilled labor. The simultaneous system of equations (1) and (2) generates analytical solutions for A_u and A_s:

$$A_u = \frac{Y^{1/(1-\alpha)}K^{-\alpha/(1-\alpha)}}{L_u}(\frac{W_uL_u}{W_uL_u + W_sL_s})^{1/\sigma} \tag{3.5}$$

and

$$A_s = \frac{Y^{1/(1-\alpha)} K^{-\alpha/(1-\alpha)}}{L_s} \left(\frac{W_s L_s}{W_u L_u + W_s L_s}\right)^{1/\sigma}. \tag{3.6}$$

$A_{s,f}$ and $A_{u,f}$ are imputed by inserting firm-level data $\{Y, K, L_u, L_s\}_f$ and city-level data $\{W_u, W_s\}_c$ into equations (3.5)–(3.6). Finally, I regress $\mathbf{A}_f = \{A_s, A_u, A_s/A_u\}_f$ on DE to examine the difference in technology across parent sources. Fixed effect at the four-digit industry level is also included in the regression. Formally,

$$\ln \mathbf{A}_{fi} = \mu + \delta_{\mathbf{A}} \cdot DE_f + \lambda'_{\mathbf{A}} X_f + \nu_i + \epsilon_{fi}, \tag{3.7}$$

where μ is the constant term, X represents firm-level control variables, and δ is the parameter of interest. i is the four-digit industry index, and ν_i is the industry-level fixed effect.

The firm-level data are from the economic survey of 2004 compiled by the National Bureau of Statistics of China. The survey reports whether a firm's owner is from emerging economies (Hong Kong, Taiwan, and Macau) or "other foreign economies." In China, nearly 90% of the latter are from developed economies. The city-level wage data are calculated based on the Investment Climate Survey (ICS) compiled by the World Bank in 2003. This study extracts, from the economic survey, multinational subsidiaries that are domiciled in the surveyed cities of the ICS 2003. Therefore, only the firms in surveyed cities are considered and the sample size is reduced.

Following the standard practice in the literature (e.g., Autor et al., 1998; Katz and Murphy, 1992), workers with junior college diploma and above are considered as skilled labor, and the rest as unskilled labor. I focus on the electronics industry for two reasons. First, it is a typical industry in which FDI is important. Second, in the electronics industry, the production located in an unskill-abundant economy such as China is very homogeneous. According to the "Electronics Industry Yearbook of China," in 2003, 90% of electronics exports from China were in the form of assembling and processing.

3.3 Results

As shown in Table 9, $1/(1-\sigma)$ is estimated to be 1.42, almost equal to the empirical value of 1.40 in the literature (e.g., Katz and Murphy, 1992; Caselli and Coleman, 2006). I then impute A_s and A_u as detailed in the previous section and run regressions (3.7) with and without control variables. The regression results are reported in Table 10. Columns (1)–(2) in Table 10 suggest that A_s is higher in developed-economy subsidiaries than in emerging-economy subsidiaries, while columns (3)–(4) show that A_u has no such difference. As expected, columns (5)–(6) illustrate the higher relative productivity of skilled labor in developed-economy subsidiaries. These findings point to the fact that the innovations in developed economies favor skilled labor. It is more costly for the MNCs of developed economies to innovate unskill-biased technologies and customize their production facilities located in developing economies than directly use their skill-biased technologies there.

The identification comes from the fact that subsidiaries from different parent sources employ different amounts of skilled labor relative to unskilled labor even though they face the same prices of local factors. This idea is illustrated by Figure 6, in which the wage share of skilled labor in payroll is larger in developed-economy subsidiaries than in emerging-economy subsidiaries. Each circle in the graph is linked to a four-digit industry in electronics manufacturing, and all the circles are weighted by size (the total value-added of multinational subsidiaries). Neither adding weights to the regressions nor excluding the large industries changes the findings. Clearly, there are substantially more data points below the 45-degree line than above it.

There are three possible concerns at this point. The first is that subsidiaries from different parent sources may produce different products, so these subsidiaries are not comparable. This is unlikely for several reasons: (i) as mentioned earlier, the production activities located in China by MNCs are very homogeneous in electronics manufacturing; (ii) all the regressions have controlled for four-digit industry fixed effects; (iii) a Kolmogorov-Smirnov test further confirms the similarity in the distribution of four-digit industries of subsidiaries across parent sources. The combined K-S statistic is 0.063 with p-value 0.44. The hypothesis of the equality of the two distributions cannot be rejected at any conventional significance level.

The second concern is that workers with different qualities may sort into subsidiaries from different sources. If this were true, unskilled labor would have also sorted, but the productivity of unskilled labor shows no difference across parent sources. It is possible that only skilled labor sorts or that the sorting of skilled labor is relatively stronger than that of unskilled labor; however, this is consistent with, rather than counter to, the argument that the technologies used in developed-economy subsidiaries favor skilled labor.

The third concern is the sensitivity of the results to different parameterization and functional forms. I have performed robustness checks using other values of σ, as well as a production function that takes the complementarity between skilled labor and capital into account. Autor et al. (1998) conclude that $1/(1-\sigma)$ is very unlikely to fall outside [1,2]. See also Caselli and Coleman (2006). I experimented with various values within [1,2] and arrived at the same finding. The alternative functional form I use is $y = \{(A_u L_u)^\sigma + [(A_s L_s)^\rho + (A_k k)^\rho]^{\sigma/\rho}\}^{1/\sigma}$. To my knowledge, there is no empirical value of ρ in the context of multinational subsidiaries located in China. I use the estimate from the U.S. firms: $\rho = -0.5$. See Krusell et al. (2000). The conclusion drawn from the original specifications still holds.

3.4 Conclusion

The technologies used by multinational subsidiaries located in a developing country are determined by the technologies used in their parent companies, as well as the local adoption costs associated with these technologies. I find that the productivity of skilled labor is higher in developed-economy subsidiaries than in emerging-economy ones, whereas the productivity of unskilled labor does not vary between the two. This constitutes strong evidence supporting the adoption of skill-biased technologies by multinational subsidiaries from developed economies despite the high adoption costs thereof.

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Appendix A

Derivations and Proofs

A.1 Derivation of profit functions

Under partnership (HH,NON), $p_H = (\frac{\Phi_H}{y_{HH,NON}})^{1-\alpha}$, so $R_{HH,NON} = p_H y_{HH,NON} = \Phi_H^{1-\alpha} y_{HH,NON}^{\alpha} = \Phi_{HH}^{1-\alpha}(\theta x_{HH,NON})^{\alpha}$. The profit is $R_{HH,NON} - cx_{HH,NON}$, the first order condition of which shows $x_{HH,NON} = \frac{\alpha R_{HH,NON}}{c}$. Plugging $x_{HH,NON}$ back to $R_{HH,NON}$ $= \Phi_H^{1-\alpha}(\theta x_{HH,NON})^{\alpha}$, I get $R_{HH,NON} = \Phi_H \theta^{\frac{\alpha}{1-\alpha}}(\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}}$. The profit function is

$$
\begin{aligned}
& R_{HH,NON} - cx_{HH,NON} \\
&= R_{HH,NON} - c\frac{\alpha R_{HH,NON}}{c} \\
&= (1-\alpha)R_{HH,NON} \\
&= (1-\alpha)\Phi_H \theta^{\frac{\alpha}{1-\alpha}}(\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}} \equiv \Psi\Phi_H\Theta.
\end{aligned}
$$

The case of partnership SS is similar.

Under partnership HS, $p_S = (\frac{\Phi_S}{y_{HS}})^{1-\alpha}$, so $R_{HS} = p_S y_{HS} = \Phi_S^{1-\alpha} y_{HS}^{\alpha} = \Phi_S^{1-\alpha}(\gamma^{\mu}\theta^{\mu}x_{HS})^{\alpha}$. The profit is $R_{HS} - cx_{HS}$, the first order condition of which shows $x_{HS} = \frac{\alpha R_{HS}}{c}$. Plugging x_{HS} back to $R_{HS} = \Phi_S^{1-\alpha}(\gamma^{\mu}\theta^{\mu}x_{HS})^{\alpha}$, I get $R_{HS} = \Phi_S \gamma^{\frac{\alpha\mu}{1-\alpha}}\theta^{\frac{\alpha\mu}{1-\alpha}}(\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}}$. The profit function is

$$
\begin{aligned}
& R_{HS} - cx_{HS} \\
& = R_{HS} - c\frac{\alpha R_{HS}}{c} \\
& = (1-\alpha)R_{HS} \\
& = (1-\alpha)\Phi_S \gamma^{\frac{\alpha\mu}{1-\alpha}} \theta^{\frac{\alpha\mu}{1-\alpha}} (\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}} \equiv \Psi \Phi_S \Gamma \Theta^{\mu}.
\end{aligned}
$$

Under partnership (HH,B), $p_H = (\frac{\Phi_H}{y_{HH,B,H}})^{1-\alpha}$, $p_S = (\frac{\Phi_S}{y_{HH,B,S}})^{1-\alpha}$, then

$$
\begin{aligned}
R_{HH,B} &= R_{HH,B,H} + R_{HH,B,S} = p_H y_{HH,B,H} + p_S y_{HH,B,S} \\
&= \Phi_H^{1-\alpha}(\theta x_{HH,B,H})^{\alpha} + \Phi_S^{1-\alpha}(\theta x_{HH,B,S})^{\alpha}.
\end{aligned}
$$

The profit is $R_{HH,B} - cx_{HH,B,H} - cx_{HH,B,S}$, the first order condition of which shows $x_{HH,B,H} = \frac{\alpha R_{HH,B,H}}{c}$, $x_{HH,B,S} = \frac{\alpha R_{HH,B,S}}{c}$.

Plugging $x_{HH,B,H}$ and $x_{HH,B,S}$ back to $R_{HH,B,H} = \Phi_H^{1-\alpha}(\theta x_{HH,B,H})^{\alpha}$ and $R_{HH,B,S} = \Phi_S^{1-\alpha}(\theta x_{HH,B,S})^{\alpha}$, respectively, I get $R_{HH,B,H} = \Phi_H \theta^{\frac{\alpha}{1-\alpha}} (\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}}$, $R_{HH,B,S} = \Phi_S \theta^{\frac{\alpha}{1-\alpha}} (\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}}$. The profit function is

$$
\begin{aligned}
& R_{HH,B} - cx_{HH,B,H} - cx_{HH,B,S} - f_{EX} \\
& = R_{HH,B,H} + R_{HH,B,S} - c\frac{\alpha R_{HH,B,H}}{c} - c\frac{\alpha R_{HH,B,S}}{c} - f_{EX} \\
& = (1-\alpha)R_{HH,B,H} + (1-\alpha)R_{HH,B,S} - f_{EX} \\
& = (1-\alpha)(\Phi_H + \Phi_S)\theta^{\frac{\alpha}{1-\alpha}} (\frac{\alpha}{c})^{\frac{\alpha}{1-\alpha}} - f_{EX} \\
& \equiv \Psi(\Phi_H + \Phi_S)\Theta - f_{EX}.
\end{aligned}
$$

A.2 The proof of Lemma 1

Define

$$\Lambda(\Theta) \equiv \pi_{HS}(\Theta) - \pi_{HH}(\Theta) - \widetilde{\pi}$$
$$= \Psi\Phi_S\Gamma\Theta^{\mu} - \Psi\Phi_H\Theta - \widetilde{\Psi}\Phi_S\widetilde{\Theta}.$$

By condition (1.10),

$$\Gamma > \frac{\Psi\Phi_H\Theta_* + \widetilde{\Psi}\Phi_S\widetilde{\Theta}}{\Psi\Phi_S\Theta_*^{\mu}},$$

so $\Lambda(\Theta^*) > 0$. If Θ is sufficiently large, so $\Lambda(\Theta) < 0$; if $\Theta \to 0$, $\Lambda(\Theta) < 0$ so there exist two values respectively $(0, \Theta^*)$ and (Θ^*, ∞) at which $\Lambda(\Theta) = 0$. Denote them by $\underline{\Theta}$ and $\overline{\Theta}$, respectively. Then, any $\Theta \in (\underline{\Theta}, \overline{\Theta})$ satisfies $\pi_{HS}(\Theta) - \pi_{HH}(\Theta) - \widetilde{\pi} > 0$ (part (ii) proved). QED.

A.3 The proof of Lemma 2

The "if" part is obvious, as condition (1.12) is stricter than condition (1.11). The "only if" part is equivalent to this claim: if $\Theta \notin (\underline{\Theta}, \overline{\Theta})$, condition (1.11) fails. The proof is as follows. Define Θ_* such that $\pi_{HS}(\Theta_*) - \widetilde{\pi} = 0$.

Case 1: $\Theta \in (0, \Theta_*]$. Since $d\pi_{HS}(\Theta)/d\Theta > 0$ for any $\Theta \in \mathbf{R}_{++}$, $\pi_{HS}(\Theta_*) - \widetilde{\pi} < 0$, so $\pi_{HS}(\Theta) - \pi_{HH}^{X_H}(\Theta) - \widetilde{\pi} < 0$.

Case 2: $\Theta \in (\Theta_*, \underline{\Theta}]$. By Lemma 1, $\pi_{HS}(\Theta) - \pi_{HH,NON}(\Theta) - \widetilde{\pi} < 0$; however, $\pi_{HS}(\Theta) - \pi_{HH,NON}^{X_H}(\Theta) - \widetilde{\pi}$ can be positive if $\pi_{HH}^{X_H}(\Theta) < \pi_{HH}(\Theta)$. If $\pi_{HS}(\Theta) - \pi_{HH,NON}^{X_H}(\Theta) - \widetilde{\pi} > 0$, it is profitable for Z_S to choose X_H instead of X_S. To get X_H, Z_S can offer X_H any profit transfer $T^{Z_S}(\Theta) \in [0, \pi_{HS}(\Theta) - \widetilde{\pi})$; but, Z_H will bid up any $T^{Z_S}(\Theta)$ by $T^{Z_H}(\Theta) = T^{Z_S}(\Theta) + \varepsilon$, where ε is a slightly positive value, because $\pi^{Z_H}(\Theta) = \pi_{HH,NON}(\Theta) - (\pi_{HS}(\Theta) - \widetilde{\pi} + \varepsilon) =$

$-(\pi_{HS}(\Theta)-\pi_{HH,NON}(\Theta)-\tilde{\pi})-\varepsilon>0$; then, Z_S will further bid up by $T^{Z_H}(\Theta)+\varepsilon'$ in return. The only equilibrium is when Z_H offers $T^{Z_H}(\Theta)=\pi_{HS}(\Theta)-\tilde{\pi}$, Z_H has no incentive to change because its reservation profit is zero, and Z_S has no incentive to bid up further. That is, $\pi^{X_H}(\Theta)=\pi_{HS}(\Theta)-\tilde{\pi}$, so $\pi_{HS}(\Theta)-\pi^{X_H}_{HH,NON}(\Theta)-\tilde{\pi}=\pi_{HS}(\Theta)-\pi_{HS}(\Theta)+\tilde{\pi}-\tilde{\pi}=0$.

Case 3: $\Theta\in[\overline{\Theta},\infty)$. Similar to Case 2, the only equilibrium is when Z_H offers $T^{Z_H}(\Theta)=\pi_{HS}(\Theta)-\tilde{\pi}$. That is, $\pi^{X_H}(\Theta)=\pi_{HS}(\Theta)-\tilde{\pi}$, so $\pi_{HS}(\Theta)-\pi^{X_H}_{HH,B}(\Theta)-\tilde{\pi}=\pi_{HS}(\Theta)-\pi_{HS}(\Theta)+\tilde{\pi}-\tilde{\pi}=0$. QED.

A.4 The proof of Proposition 3

Notice that $\sigma_{HS}/\sigma_{HH,B}=[V(\overline{\Theta})-V(\underline{\Theta})]/[1-V(\overline{\Theta})]$.

Parts (i) and (ii). The goal is to show $\frac{d\overline{\Theta}}{d\gamma}>0$, $\frac{d\overline{\Theta}}{d\mu}>0$, $\frac{d\underline{\Theta}}{d\gamma}<0$, and $\frac{d\underline{\Theta}}{d\mu}<0$.

At $\overline{\Theta}$, define $\Xi=\pi_{HS}(\overline{\Theta})-\pi_{HH,B}(\overline{\Theta})-\overline{\pi}=0$. By implicit function theorem,

$$\frac{d\overline{\Theta}}{d\gamma}=-\frac{\frac{d\Xi}{d\gamma}}{\frac{d\Xi}{d\overline{\Theta}}}=-\frac{\frac{d\pi_{HS}(\overline{\Theta})}{d\gamma}}{\frac{d\pi_{HS}(\overline{\Theta})}{d\overline{\Theta}}-\frac{d\pi_{HH,B}(\overline{\Theta})}{d\overline{\Theta}}},$$

$$\frac{d\overline{\Theta}}{d\mu}=-\frac{\frac{d\Xi}{d\mu}}{\frac{d\Xi}{d\overline{\Theta}}}=-\frac{\frac{d\pi_{HS}(\overline{\Theta})}{d\mu}}{\frac{d\pi_{HS}(\overline{\Theta})}{d\overline{\Theta}}-\frac{d\pi_{HH,B}(\overline{\Theta})}{d\overline{\Theta}}}.$$

Note that $\frac{d\pi_{HS}(\overline{\Theta})}{d\overline{\Theta}}-\frac{d\pi_{HS,B}(\overline{\Theta})}{d\overline{\Theta}}<0$, $\frac{d\pi_{HS}(\overline{\Theta})}{d\gamma}>0$, and $\frac{d\pi_{HS}(\overline{\Theta})}{d\mu}>0$, so $\frac{d\overline{\Theta}}{d\gamma}>0$, $\frac{d\overline{\Theta}}{d\mu}>0$.

At $\underline{\Theta}$, define $\Xi'=\pi_{HS}(\underline{\Theta})-\pi_{HH,NON}(\underline{\Theta})-\overline{\pi}=0$. Then,

$$\frac{d\underline{\Theta}}{d\gamma}=-\frac{\frac{d\Xi'}{d\gamma}}{\frac{d\Xi'}{d\underline{\Theta}}}=-\frac{\frac{d\pi_{HS}(\underline{\Theta})}{d\gamma}}{\frac{d\pi_{HS}(\underline{\Theta})}{d\underline{\Theta}}-\frac{d\pi_{HH,NON}(\underline{\Theta})}{d\underline{\Theta}}},$$

$$\frac{d\underline{\Theta}}{d\mu}=-\frac{\frac{d\Xi'}{d\mu}}{\frac{d\Xi'}{d\underline{\Theta}}}=-\frac{\frac{d\pi_{HS}(\underline{\Theta})}{d\mu}}{\frac{d\pi_{HS}(\underline{\Theta})}{d\underline{\Theta}}-\frac{d\pi_{HH,NON}(\underline{\Theta})}{d\underline{\Theta}}}.$$

Note that $\frac{d\pi_{HS}(\underline{\Theta})}{d\underline{\Theta}} - \frac{d\pi_{HH,NON}(\underline{\Theta})}{d\underline{\Theta}} > 0$, $\frac{d\pi_{HS}(\underline{\Theta})}{d\gamma} > 0$, and $\frac{d\pi_{HS}(\underline{\Theta})}{d\mu} > 0$, so $\frac{d\underline{\Theta}}{d\gamma} < 0$, and $\frac{d\underline{\Theta}}{d\mu} < 0$.

Part (iii). $\sigma_{HS} = 1 - \left(\underline{\Theta}/\overline{\Theta}\right)^{\zeta}$, $\underline{\Theta} < \overline{\Theta}$, so $\frac{d\sigma_{HS}}{d\zeta} > 0$. Similarly, $\frac{d\sigma_{HH,B}}{d\zeta} < 0$. QED.

Appendix B

Data Details and Supplementary Results

B.1 Details on the data

The primary data source is the Annual Surveys of Industrial Production from 2000 through 2003 conducted by the National Bureau of Statistics of China. These survey data are proprietary.

Each firm in the survey has an ID number. There are about 10 duplicate IDs in each year, and I dropped these observations. The dataset for the years 2000-2004 has 162,869, 169,017, 181,545, and 196,206 observations, respectively. Then, data for all years are merged by ID number. Further data cleaning takes three steps. First, firms outside manufacturing industries (four-digit industry code <1311 or >4392) are dropped, which reduces the sample size by 60,415. Second, firms that are not in normal operation (i.e., status code does not equal 1) are dropped, which reduces the sample size by 16,141. Third, observations with wrong industry and area codes are also dropped, which reduces the sample size by about 140.

My study focuses on domestically owned firms (registration type code <200) that export some or all of their outputs, and foreign-owned firms (registration type codes: 230 and 330) that export all of their outputs. Keeping these firms only, my working dataset has 512,832 observations. I then drop the firms that are present only once in the four-year time span, because their productivity cannot be estimated using the Levinsohn-Petrin method. Descriptive statistics are reported in Table S1. The within-border partnership serving the Chinese market only, within-border partnership serving both markets, cross-border partnership at arm's length, and cross-border partnership in vertical integration have 338,532, 64,335, 15,845, and 14,107 observations, respectively.

B.2 Supplementary results

Chapter 2 regresses TFP on either partnership types or organizational forms. This approach is useful because of its simplicity in estimating productivity differences among the three partnership types or between the two organizational forms. The alternative specification, i.e., regressing partnership on TFP, is more intuitive as it suggests how productivity predicts the choices between partnership types or organizational forms.

Table S2 estimates a multinomial logit model. The dependent variable is partnership type: within-border partnership serving the Chinese market only (0), cross-border partnership (1), and within-border partnership serving both Chinese and overseas market (2). They are respectively linked to partnerships (HH,NON), HS, and (HH,B) in the text. The reference group is (HH,NON). Columns (1)–(2) show that producers with higher productivity have a higher probability of choosing partnership HS relative to (HH,NON), and an even higher probability of choosing partnership (HH,B) relative to (HH,NON). Control variables are as in the text. Also as in the text, columns (3)–(4) include tax payment as an additional control variable, and columns (5)–(6) and (7)–(8) consider the apparel industry and the electronics industry. All columns lead to the same finding.

Table S3 uses the same specification as Table S2 but employs an ordered logit model. The theoretical model suggests that HS is a better choice for producers that are qualified for (HH,NON) and have sufficiently high productivity; similarly, (HH,B) is a better choice for producers that are qualified for HS and have sufficiently high productivity. Thus, I order the three partnerships as 0, 1, 2, and examine whether productivity premium in the form of "upgrade probability" is present between the three partnership types. As expected, productivity has a positive and significant coefficient in all columns.

Table S4 uses a logit model to examine the choice between organizational forms under cross-border partnership: arm's length (0) and vertical integration (1). Its structure is similar to Table 7 and Table S2. Notably, the magnitude of the productivity increase associated with productivity is smaller in column (4) than in column (3). This is possibly because productivity heterogeneity becomes less significant in industries with a comparative disadvantage. Specifically, China has a comparative disadvantage in industries with high sophistication, such as electronics. Therefore, the productivity dispersion of Chinese electronics firms is smaller than average, and the productivity difference across organizational forms becomes smaller.

Appendix C

Tables and Figures

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Table 1: Theoretical and Empirical Partnership Types

Theory	Data	
Partnership Types & Organizational Forms	Ownership	Sales
(HH, NON)	domestic	domestic
(HH, B)	domestic	domestic and overseas
(HS,I)	overseas	overseas
(HS,O)	domestic	overseas

Table 2: Shares of Different Partnership Types and Organizational Forms in Exporters

	Partnership HS				Partnership (HH,B)	
	Arm's length (HS,O)		Vertical integration (HS,I)			
	Value	Number	Value	Number	Value	Number
2000	11.20%	10.70%	28.10%	22.90%	60.70%	66.40%
2001	12.20%	13.30%	28.50%	21.30%	59.20%	65.50%
2002	11.30%	13.90%	29.10%	21.40%	59.50%	64.70%
2003	11.70%	13.40%	31.10%	21.80%	57.20%	64.80%

Table 3: Productivity across Partnerships

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cross-border partnership (HS dummy)	0.223***	0.207***	0.205***	0.203***	0.198***	0.192***	0.108***	0.267***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.008)	(0.015)
Within-border partnership & serving both markets (HHB dummy)	0.357***	0.352***	0.352***	0.335***	0.301***	0.348***	0.205***	0.379***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.006)	(0.005)	(0.010)	(0.012)
Specification	FE	FE	RE	FE	FE	FE	FE	FE
Sample	All	All	All	All	Special Zones	Non-Special Zones	Apparel	Electronics
Control vars.	No	Yes	Yes	Yes, with tax	Yes, with tax	Yes, with tax	Yes, with tax	Yes, with tax
t-test [p-value]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
No. of obs.	376,390	376,390	376,390	376,390	130,337	246,053	12,640	18,107
No. of inds.	752	752	752	752	746	748	4	42
R^2	0.05	0.06	0.07	0.08	0.09	0.08	0.10	0.16

Notes: The dependent variable is TFP calculated with Levinsohn-Petrin estimates. Firms undertaking within-border partnership and serving the Chinese market only, i.e., (HH,NON), is the reference group. Control variables are profit margin, capital intensity, and regional population. Industry (four-digit) and year fixed effects are controlled for in columns (1)-(2) and (4)-(8), while random effects are used in column (3). Columns (4)-(8) include tax payment as an additional control variable. Columns (5)-(6) use subsamples of firms located where there are special zones, including export-promotion zones (EPZs) and free trade zones (FTZs); see text for details. Columns (7) and (8) use subsamples of firms in two-digit industries apparel and electronics, respectively. Robust standard errors in parentheses. The t-test examines if the coefficients of the two dummy variables are equal (H0: equal). "No. of inds." reports the number of four-digit industries in the used sample. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 4: Productivity across Partnerships, Quantile Regression

	(1)	(2)	(3)	(4)	(5)
	10%	25%	50%	75%	90%
Cross-border partnership (HS dummy)	0.184***	0.138***	0.131***	0.143***	0.153***
	(0.006)	(0.004)	(0.003)	(0.004)	(0.005)
Within-border partnership & serving both markets (HHB dummy)	0.240***	0.226***	0.278***	0.345***	0.387***
	(0.004)	(0.002)	(0.002)	(0.003)	(0.004)
Difference	0.056	0.088	0.147	0.202	0.234
No. of obs.	376,390	376,390	376,390	376,390	376,390
No. of inds.	30	30	30	30	30
Pseudo R^2	0.17	0.08	0.06	0.07	0.10

Notes: The dependent variable is TFP calculated with Levinsohn-Petrin estimates. Firms undertaking within-border partnership and serving the Chinese market only, i.e., (HH,NON), is the reference group. The five columns use five different quantiles. The row "difference" reports the differences between the coefficients of the two dummy variables. Control variables are profit margin, capital intensity, and regional population. Two-digit industry fixed effect is controlled for in all columns, and "No. of inds." reports the number of two-digit industries in the used sample. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 5: Partnership Switchers and Ex-ante Productivity

	(1)	(2)
Dummy: would switch to cross-border partnership (PRE-HS)	0.057***	0.059***
	(0.012)	(0.012)
Dummy: would switch to within-border partnership and serving two markets (PRE-HHB)	0.196***	0.195***
	(0.005)	(0.005)
Control vars.	No	Yes
t-test [p-value]	[0.00]	[0.00]
No. of obs.	334,469	334,469
No. of inds.	750	750
Rˆ2	0.01	0.02

Notes: The dependent variable is TFP calculated with Levinsohn-Petrin estimates. The firms that remain under partnership (HH,NON) in the surveyed periods is the reference group. See text for details on the two dummy variables. Control variables are profit margin, capital intensity, and regional population. Industry (four-digit) and year fixed effects are controlled for in column (2). Robust standard errors in parentheses. The t-test examines if the coefficients of two dummy variables are equal (H0: equal). "No. of inds." reports the number of four-digit industries in the used sample. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 6: Technology Intensity, Productivity Dispersion, and Local Infrastructures and Institutions

	(1)	(2)	(3)	(4)
HITECH	-0.782***	-1.488***	-1.088**	-0.782**
	(0.173)	(0.300)	(0.450)	(0.397)
DISP	-0.306***	-0.618**	-3.535***	-0.306**
	(0.071)	(0.247)	(0.563)	(0.136)
INST	0.470***	0.620***	2.073***	0.470**
	(0.089)	(0.121)	(0.124)	(0.234)
Specification	OLS/full sample	Nonzero	Tobit	Three-way cluster
No. of obs.	2062	1044	2062	2062

Notes: The dependent variable is the ratio of the number of firm undertaking cross-border partnership (HS) to that of firms undertaking within-border partnership and serving both markets (HH,B) at the industry-province-year level. HITECH is an industry-level dummy variable for high technology intensity. DISP is an industry-year-level measure of productivity dispersion. INST is a province-level measure of local institutional quality. See text for details on these measures. Control variables are capital intensity and provincial population. Column (1) uses the full sample and regular OLS estimation. Column (2) excludes observations whereof the dependent variable equals 0. Column (3) uses Tobit instead of OLS estimation. Column (4) uses three-way clustering; see text for details. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 7: Productivity across Organizational Forms in Cross-Border Partnership

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dummy: vertical integration	0.139***	0.136***	0.139***	0.133***	0.124***	0.115***	0.113***	0.129***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.009)	(0.008)	(0.010)	(0.032)
Specification	FE	FE	RE	FE	FE	FE	FE	FE
Sample	All	All	All	All	Special Zones	Non-Special Zones	Apparel	Electronics
Control vars.	No	Yes	Yes	Yes, with tax	Yes, with tax	Yes, with tax	Yes, with tax	Yes, with tax
No. of obs.	376,390	376,390	376,390	376,390	130,337	246,053	12,640	18,107
No. of inds.	752	752	752	752	746	748	4	42
R^2	0.05	0.06	0.07	0.08	0.09	0.08	0.10	0.16

Notes: The dependent variable is TFP calculated with Levinsohn-Petrin estimates. All firms are in cross-border partnership. Producers at arm's length (HS,O) is the reference group. Control variables are profit margin, capital intensity, and regional population. Industry (four-digit) and year fixed effects are controlled for in columns (1)-(2) and (4)-(8), while random effects are used in column (3). Columns (4)-(8) include tax as an additional control variable. Columns (5)-(6) use subsamples of firms located where there are special zones, namely either export-promotion zones (EPZs) or free trade zones (FTZs); see Section 3.2 for details on them. Columns (7) and (8) use subsamples of firms in two-digit industries apparel and electronics, respectively. Robust standard errors in parentheses. "No. of inds." reports the number of four-digit industries in the used sample. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 8: Organizational-Form Switchers and Ex-ante Productivity

	(1)	(2)
Dummy: would switch to integration	0.110*	0.098**
	(0.057)	(0.049)
Control vars.	No	Yes
t-test [p-value]	[0.00]	[0.00]
No. of obs.	7358	7358
No. of inds.	28	28
Rˆ2	0.00	0.10

Notes: The dependent variable is TFP calculated with Levinsohn-Petrin estimates. The firms that remain under organizational form (HS,O) in the surveyed periods is the reference group. Control variables are profit margin, capital intensity, and regional population. Industry (four-digit) and year fixed effects are controlled for in column (2). Robust standard errors in parentheses. "No. of inds." reports the number of four-digit industries in the used sample. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 9: Estimation of the Elasticity of Substitution

Dependent variable:	ln
Developed-economy dummy	0.22**
	(0.09)
ln Ws/Wu	-1.42***
	(0.51)
ln GDP per capita	-0.62
	(0.44)
Share of population with college education	-0.05
	(0.10)
Constant	5.52
	(3.80)
No. of obs.	846
F-test (p-value)	(0.00)
R-square	0.25

Notes: Fixed effect at the four-digit industry level has been controlled for. The F-test examines the joint significance of all coefficients (H0: all equal 0). Coefficients are rounded to their nearest neighbors. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table 10: Main Results

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	lnAs	lnAs	lnAu	lnAu	lnAs-lnAu	lnAs-lnAu
Developed-economy dummy	0.72***	0.78***	0.12	0.12	0.59***	0.65***
	(0.18)	(0.18)	(0.12)	(0.12)	(0.21)	(0.21)
Control variables	No	Yes	No	Yes	No	Yes
No. of obs.	837	837	846	846	834	834
R-square	0.15	0.17	0.18	0.18	0.19	0.20

Notes: Fixed effect at the four-digit industry level has been controlled for. Control variables are firm size (employment) and age. Coefficients are rounded to their nearest neighbors. Constant term is suppressed. *, significant at 10%; **, significant at 5%; ***, significant at 1%.

Table S1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.
Employment	432819	312.1014	1176.646
Exported value	432819	7893.862	104344.1
Profit	432819	2143.871	35735.33
Fixed assets	432819	26536.57	303054.2
Sales	432819	55765.27	417282.3
Intermediates	432819	43643.36	329399.6
Tax payment	432819	112.9358	1414.343

Table S2: Multinomial Logit Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline		With Tax Included		Apparel		Electronics	
	HS	(HH,B)	HS	(HH,B)	HS	(HH,B)	HS	(HH,B)
Productivity	0.715***	1.402***	0.804***	1.282***	0.778***	1.261***	1.198***	1.471***
	(0.016)	(0.012)	(0.017)	(0.012)	(0.057)	(0.062)	(0.069)	(0.055)
No. of obs.	376390	376390	376390	376390	12640	12640	18107	18107

Notes: The dependent variable is partnership type: 0 (HH,NON), 1 (HS), and 2 (HH,B). See text for their definitions. Productivity is measured by TFP calculated using Levinsohn-Petrin estimates. Control variables are profit margin, capital intensity, and regional population. Columns (1)-(2) are the baseline results. Columns (3)-(4) include tax payments as an additional control variable. Columns (5)-(6) and (7)-(8) use subsamples of firms in two-digit industries apparel and electronics, respectively. Constant term is suppressed. ***, significant at 1%.

Table S3: Partnership Choice, Ordered Logit Results

	(1)	(2)	(3)	(4)
Productivity	1.213***	1.083***	1.003***	1.319***
	(0.010)	(0.010)	(0.046)	(0.045)
No. of obs.	376390	376390	12640	18107

Notes: The dependent variable is partnership type: 0 (HH,NON), 1 (HS), and 2 (HH,B). See text for their definitions. Productivity is measured by TFP calculated using Levinsohn-Petrin estimates. Control variables are profit margin, capital intensity, and regional population. Column (1) is the baseline result. Column (2) includes tax payments as an additional control variable. Columns (3) and (4) use subsamples of firms in two-digit industries apparel and electronics, respectively. Constant term is suppressed. ***, significant at 1%.

Table S4: Ornigazational Form Choice, Logit Results

	(1)	(2)	(3)	(4)
Productivity	0.306***	0.309***	0.340***	0.143***
	(0.012)	(0.012)	(0.030)	(0.025)
Observations	22016	22016	3888	1282

Notes: The dependent variable is the organization form of cross-border production: 0 (HS,O) and 1 (HS,I). See text for their definitions. Productivity is measured by TFP calculated using Levinsohn-Petrin estimates. Marginal effects are reported. Control variables are profit margin, capital intensity, and regional population. Column (1) is the baseline result. Column (2) includes tax payments as an additional control variable. Columns (3) and (4) use subsamples of firms in two-digit industries apparel and electronics, respectively. Constant term is suppressed. ***, significant at 1%.

Figure 1: The Contracting Process

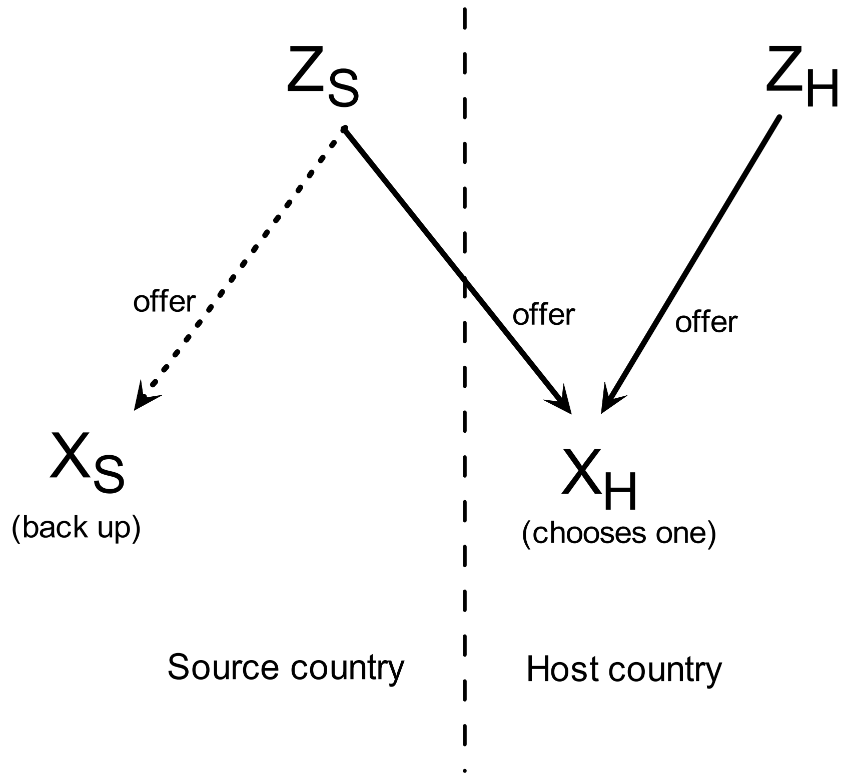


Figure 2: Ex-ante Productivity and Partnership Type

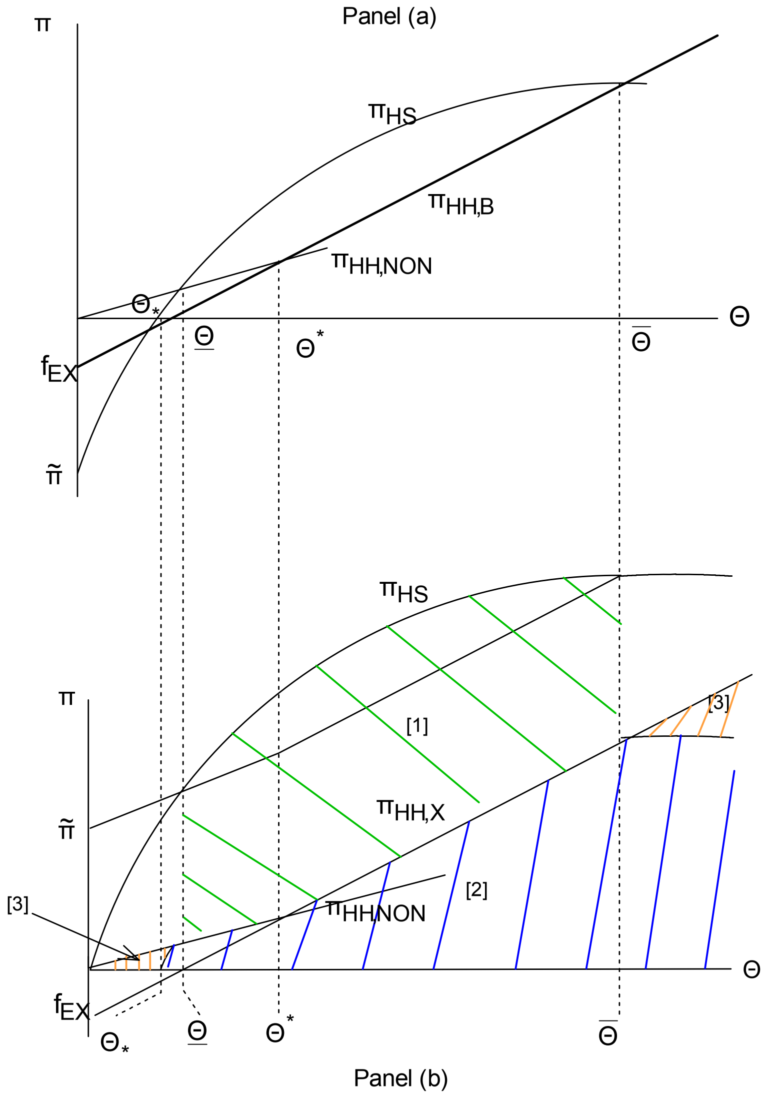


Figure 3: Organizational Forms

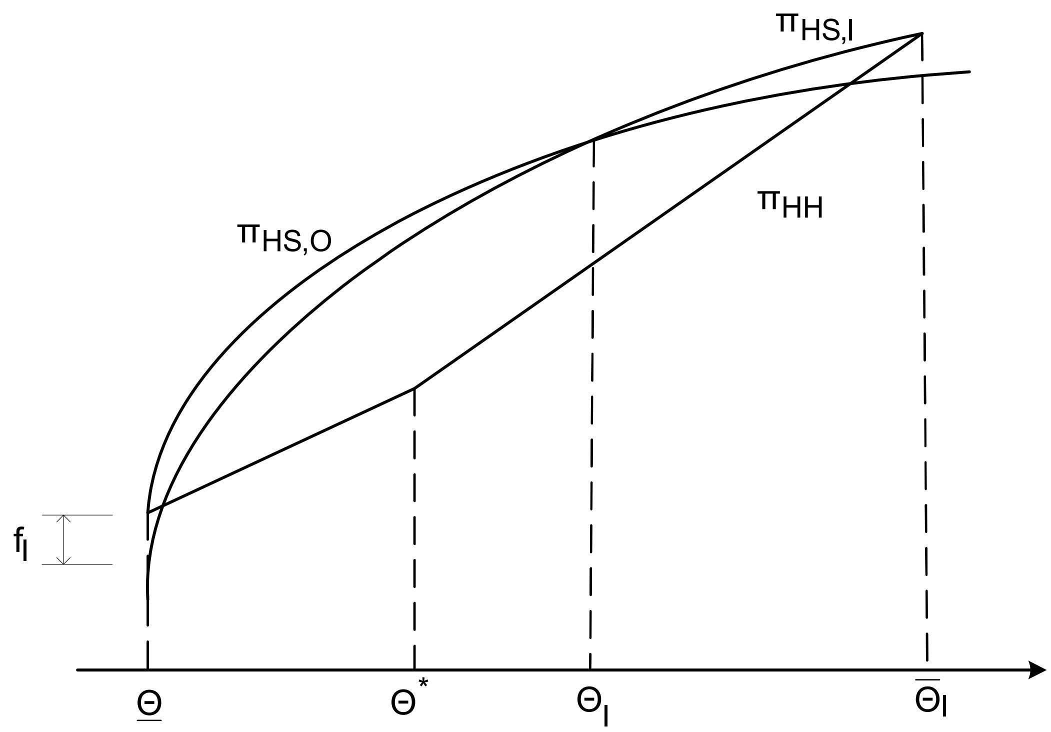


Figure 4: Different Functional Forms

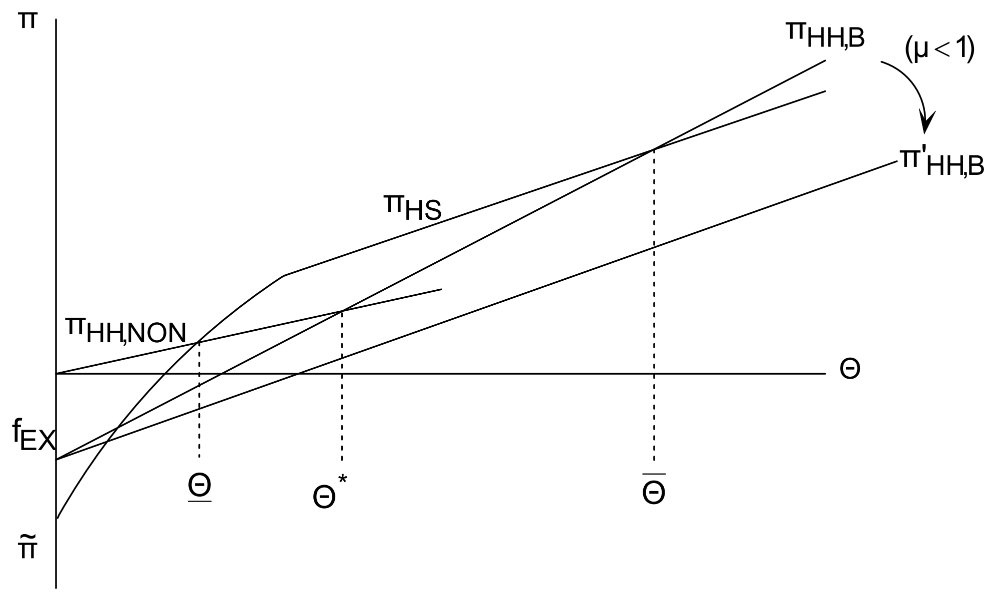
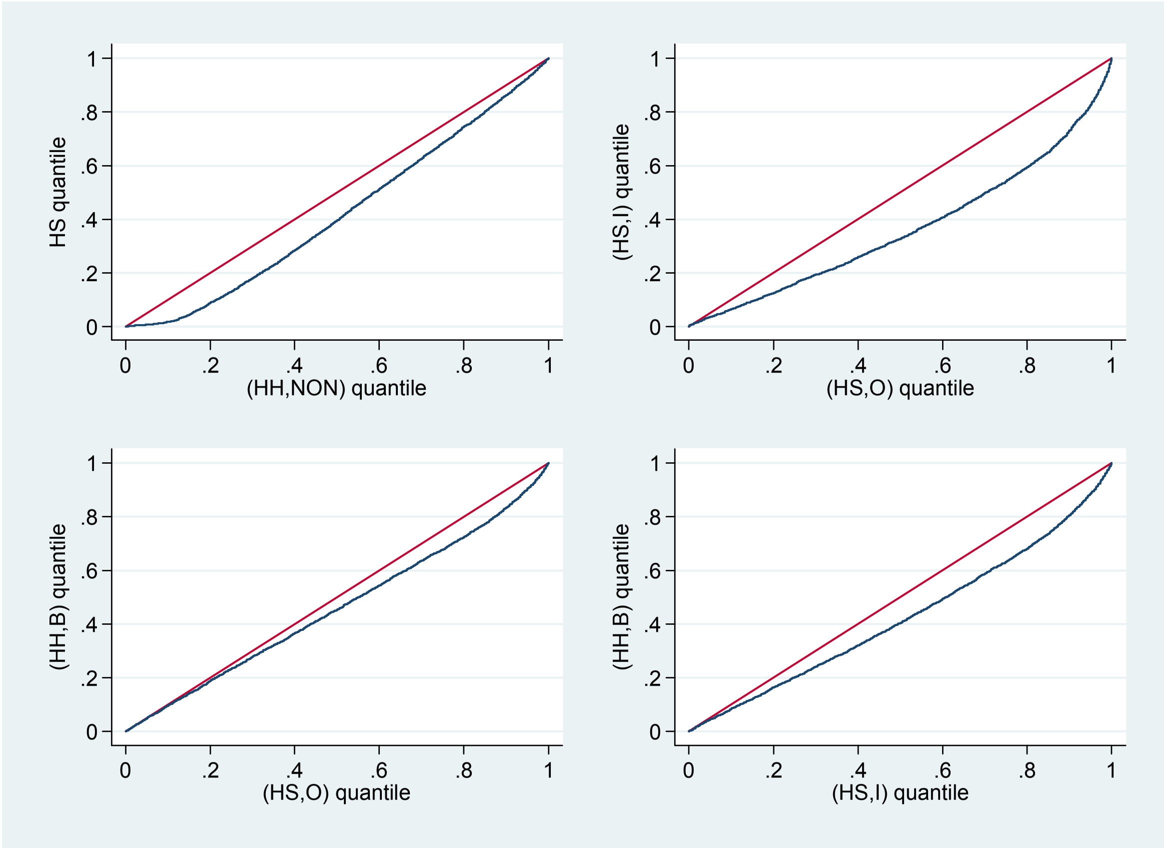
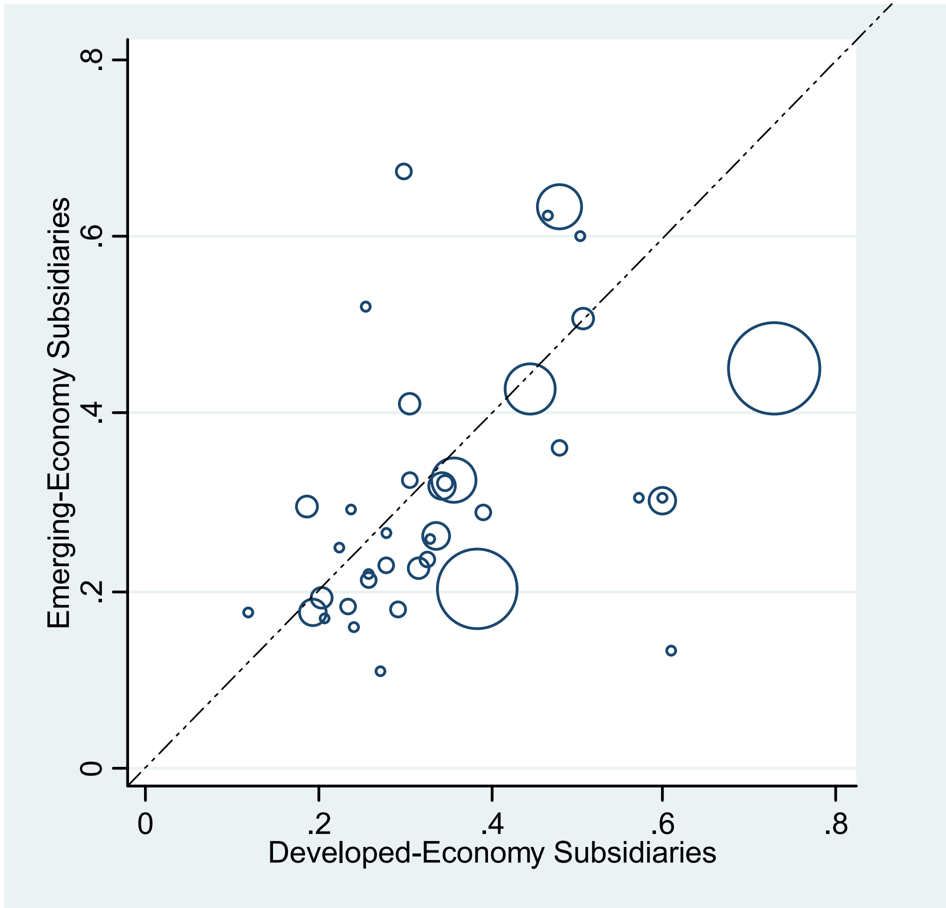


Figure 5: Relative Distribution of Productivity across Partnership Types and Organizational Forms



Notes: If the distributions of a variable associated with two groups are the same, the relative cumulative density function will graphically coincide with the diagonal. The upper-left, upper-right, lower-left, and lower-right panels respectively present TFP comparisons of (HH,NON) vs. HS exporters, (HS,O) vs. (HS,I), (HS,O) vs. (HH,B), and (HS,I) vs. (HH,B).

Figure 6: The Wage Share of Skilled Labor across Four-Digit Industries



Notes: Each circle is linked to a four-digit industry in electronics manufacturing. All the circles are weighted by size (the total value added of multinational subsidiaries). The dotted line is a 45-degree line. The five largest circles refer to the manufacturing of telecommunication equipment, air-conditioner, computer system, mobile communication equipment, and integrated circuit board.