The Determinants of Intrafirm Trade in Export Processing: Theory and Evidence from China*

Ana Fernandes†
University of Sussex and CEP

Heiwai Tang‡
HKUST and Tufts University

This Version: June 20, 2009.

Abstract

This paper investigates the determinants of integration versus outsourcing by exploiting the co-existence of two regulatory trade regimes for export-processing in China. Under the import-and-assembly regime, Chinese plants have control rights and ownership over the imported materials. Under the pure-assembly regime, ownership over the materials shipped to China remains with the foreign client. To guide the empirical analysis, we extend the model by Antràs and Helpman (2004) to include component search in processing trade. The model predicts that ownership and control rights over components should be allocated to the party whose investments are relatively more important for production. As such, headquarter intensity and the prevalence of intrafirm trade are positively correlated across sectors under import-and-assembly; the relationship is ambiguous under pure-assembly. Using detailed product-level export data for China, we examine the theoretical predictions and find that under import-and-assembly, the share of intrafirm exports is increasing in the intensity of headquarter inputs across sectors, and is decreasing in the contractibility of inputs. These results support existing theories on the determinants of intrafirm trade. However, under pure-assembly, we find little support for existing theories on intrafirm trade that focus on the contract incompleteness and the relative importance of relationship-specific investments. Larger industry productivity dispersion is associated with a larger share of intrafirm exports under pure-assembly but not under import-and-assembly. These results are consistent with our model predictions.

Key Words Intra-firm trade, Vertical integration, Export processing, Outourcing
JEL Classification Numbers: F14, F23: L14, L33

---

*We are grateful for Larry Qiu, Shang-Jin Wei, Stephen Yeaple and participants in Sussex and Trinity College, Dublin for insightful discussions and comments. We thank Randy Becker, Joseph Fan, Nathan Nunn and Peter Schott for kindly sharing with us their data. We also thank Nuffield Foundation for its financial support. All errors are our own.

†Email: A.Fernandes@lse.ac.uk
‡Email: hwtang@ust.hk

1 Introduction

International fragmentation of production has become an increasingly important feature of international trade. Between 1990 and 2001, the growth rate of foreign affiliate sales outpaced that of exports of goods and non-factor services by 7 percent per year.[1] Motivated by the substantial increase in foreign affiliate sales, a growing theoretical literature adopts approaches from the theory of the firm to study the determinants of intrafirm trade.[2] Nevertheless, empirical evidence is scant, and focused only on the developed world. In this paper, we use detailed product-level trade data to study the determinants of intrafirm trade in export processing in China. In focusing on the input supplier's side of a trade relationship, we hope to gain an insight into the understanding of insourcing versus outsourcing in world trade. By focusing on a ripidly growing developing country, we complement existing findings based on the headquarter's side of the story in developed countries.

To promote export-led growth, the Chinese government offers substantial tariff reduction for export-processing plants. Export processing played an important role in China's economic development and accounted for more than half of its exports in recent years. Specific to China, export processing has been governed under two regulatory regimes since the early 1980s, namely pure-assembly and import-and-assembly. The main difference between the two regimes lies in the allocation of control rights and ownership of the imported components. Under the pure-assembly regime, a foreign firm supplies a Chinese plant with components and hires the firm to process them into finished products. The foreign firm retains ownership of the components throughout the production process. Under the import-and-assembly regime, an assembly plant in China searches for and imports inputs of its own accord, processes them, and sells the finished products to a foreign buyer.

We take advantage of this special policy feature in China to better understand the prevalence of intrafirm versus arms-length trade. We argue that the control rights and ownership of components can affect the foreign client's organizational decisions, and thus shape the industrial structure of intrafirm trade. To guide our empirical exploration on the determinants of intrafirm trade and deepen our understandings of export processing, we extend Antràs and Helpman (2004) North-South trade model with heterogeneous firms to incorporate firms' component-search decisions. Under pure-assembly, the final-good producer in the North searches for and owns the imported components; whereas under import-and-assembly, the subsidiary in the South searches for and owns the imported components. When investments cannot be contractible ex-ante, control rights and ownership over components enhance the outside options of the owners in ex-post bargaining over the surplus from the relationship. In addition, since all investments are complementary to each other, control rights over components, together with ownership of the plant's assets, should be given to the party whose inputs are more important in production. This prediction is in the spirit

[1] See Helpman (2006).

[2] Seminal work includes McLaren (2000), Antràs (2003, 2005), Grossman and Helpman (2002, 2003, 2004, 2005) and Antràs and Helpman (2004, 2008).

of Antràs (2003) and Antràs and Helpman (2004, 2008), who argue that to maximize operating profits, the headquarter firm chooses an organizational form that gives a higher bargaining power to the party whose inputs are more important in production.

Our model thus predicts that in sectors with higher values of headquarter intensity, not only integration becomes more prevalent, pure-assembly also becomes more prevalent relative to import-and-assembly. With the assumption that pure-assembly is associated with a higher fixed cost relative to import-and-assembly, and that integration is associated with a higher fixed cost than outsourcing, our model predicts that in assembly-intensive sectors, outsourcing, and possibly entirely import-and-assembly outsourcing, is the only production mode in equilibrium. Only if the final-good producer commands a substantial cost advantage over component search, no firms will operate under pure-assembly in assembly-intensive sectors because of the higher fixed cost of production. On the other hand, integration is found only in headquarter-intensive sectors. In particular, considering firm heterogeneous productivity, the model predicts that for the import-and-assembly regime, the fraction of integrated firms is increasing in headquarter intensity across sectors. Perhaps surprisingly, for the pure-assembly regime, we find an ambiguous relationship between sectoral headquarter intensity and the prevalence of integration. The reason is that when the value of headquarter intensity increases, some firms would switch from the import-and-assembly regime to the outsourcing mode under pure-assembly, while some firms would switch from outsourcing to integration within pure-assembly. The net impact on the composition of organizational modes within the pure-assembly regime is ambiguous.

An important theoretical prediction emanating from Antràs and Helpman (2004) is that productivity dispersion and the share of intrafirm trade are positively correlated in headquarter-intensive industries. Our model shows that not only productivity dispersion is positively related to the share of intrafirm trade, the relationship depends on the trade regime. With higher fixed costs associated with integration than outsourcing, only the most productive production units choose integration as the optimal organizational form. Since the most productive firms already self-select into pure-assembly, the relationship between productivity dispersion and the prevalence of intrafirm trade is expected to be stronger under pure-assembly than under import-and-assembly.

We examine the model predictions using detailed product-level trade data collected by China's customs. In particular, we regress the share of intrafirm trade on various measures of headquarters intensities at the HS 6-digit level for each regime, respectively. For the import-and-assembly regime, a positive relationship is found between the share of intrafirm trade and the intensity of headquarters inputs (skill and capital-equipment), which are consistent with the main predictions of Antràs (2003). The results are robust when we restrict exports only to the U.S. and different country groups based on income levels, as well as when country fixed effects are included in regressions on a sample of exports to each country. For exports under the pure-assembly regime, no significant relationship is found between headquarter intensities and intrafirm trade. We find evidence that productivity dispersion and the share of intrafirm trade are positively correlated across sectors.

These results are consistent with the benchmark case of our model when only the most productive firms integrate with assembly plants under pure-assembly.

Antràs and Helpman (2008) introduce partial contractibility of investments. An important prediction is that besides headquarter intensity, the degree for which investments are contractible is an important consideration for vertical integration. We also examine this prediction, and find that for industries with higher values of headquarter intensity, an increase in the contractibility of the supplier's inputs is associated with a lower share of intrafirm trade under import-and-assembly.

We also explore the large cross-province variation in the quality of legal institutions in China to examine the impact of institutional quality on the prevalence of intrafirm trade across provinces and sectors. Interestingly, our results depend on how we measure headquarter intensity. If skill intensity is used as a proxy for headquarter intensity, we find that an improvement in legal institution in the province has no impact on the share of intrafirm trade, although it is associated with a negative impact in sectors with higher headquarter intensity. If we use capital or equipment intensities as proxies for headquarter intensity, the opposite results are obtained – more intrafirm trade is observed when legal institution improves, particularly in the more headquarter-intensive sectors. It is important to note that Antràs and Helpman (2008) show theoretically that the impact of increased contractibility of the supplier's inputs on intrafirm trade is ambiguous.

Previous empirical studies of intrafirm trade focused only on developed countries. This strand of research includes Yeaple (2006), Nunn and Trefler (2008), and Bernard, Jensen, Redding and Schott (2008) who provide sector-level evidence for the U.S.; and Defever and Toubal (2007) and Corcos, Delphine, Mion and Verdier (2008) who provide firm-level evidence for France. Yeaple, Nunn and Trefler, Bernard, et al. find empirical support for the theoretical predictions of existing models. In this literature, imports within multinationals' boundaries were assumed to be shipped from foreign subsidiaries to the US headquarters. However, a significant share of the intrafirm imports originates from the foreign headquarters of the U.S. subsidiaries, especially from the subsidiaries located in developed countries (Nunn and Trefler, 2008). A strength of our paper is that we only consider exports from export-processing assembly plants who produce solely for sales in the headquarters' countries. By focusing on exports from the subsidiaries to the multinational headquarters, we can obtain cleaner results which, in this case, validate the existing theoretical models that have so far put sourcing decisions by the headquarters in the North at the center of analysis. Defever and Toubal find that the most productive firms tend to outsource, while Corcos et al. find that the least productive ones outsource. These two findings are consistent with Antràs and Helpman (2004), but require different assumptions about the ranking of fixed costs associated with different organizational structures. Importantly, these studies on France show that intra-industry differences in factor intensity matters as much as inter-industry differences in shaping the industrial structure of sourcing modes.

Feenstra and Hanson (2005) study the control rights of components and export processing in

China. They investigate both theoretically and empirically the prevalence of foreign ownership in the import-and-assembly regime in China. The focus of our paper is to study the sectoral determinants of intrafirm trade across the two trade regimes, focusing on the control rights of components as an important determinant of firms' organizational choices. While Feenstra and Hanson also explore the impact of cross-province variation in the quality of legal institutions on the prevalence of integration in the two regimes, we focus on the effects on integration arising from the interaction between the institutional quality of a province and the headquarter intensity of a sector.

The paper is organized as follows. Section 2 discusses briefly the background of export processing in China. Section 3 develops the theoretical framework for our empirical investigation. Section 4 describes our data source. Section 5 examines our theoretical predictions empirically. The last section concludes.

2 Export Processing in China

In the hope of obtaining foreign technology, generating employment and economic growth, since the early 1980s China implemented various policies to promote exports and foreign direct investments. One of the key policy tools is to allow goods and materials imported duty-free for export processing. Legally, export processing has been regulated by Chinese customs under two regimes: pure-assembly and import-and-assembly. Chinese assembly plants and foreign final-good producers play different roles under these two regimes.

Export processing plays a major role in China's foreign trade. As Table 1 shows, export processing trade accounted for about 55 percent of total exports from China in 2005, and more than 80 percent of foreign-owned enterprises' exports. Among export-processing trade, import-and-assembly is the more common mode of exports. Table 2 shows that 78 percent of total export-processing exports was classified under import-and-assembly in 2005, with the remaining classified as pure-assembly exports. Of these import-and-assembly exports, 76 percent was associated with foreign affiliated plants, which we take as intra-firm exports. While pure-assembly exports account for 22 percent of export-processing trade. The share of foreign-affiliate exports for pure-assembly export is about 44 percent. In short, foreign ownership prevails in the import-and-assembly regime, but not in the pure-assembly regime.

Under pure-assembly, a foreign final-good producer supplies a Chinese assembly plant with materials from abroad. The plant then assembles these materials into final products, which are shipped to the foreign client for sales outside China. It is important to note that under this regime, the foreign final-good producer owns the materials throughout the production process. To obtain a license from China's customs for trading under this regime, the terms of the transactions need to be specified in written contracts, and to be presented to the Chinese authority in advance for approval.[3]

Under import-and-assembly, the Chinese plant takes a more active role. In particular, instead of passively receiving materials from the foreign client, an assembly plant searches for materials for assembly processing. Importantly, the assembly plant retains ownership throughout the production process. Unlike a pure-assembly plant, it may purchase the same kind of components and produce for multiple foreign final-good producers. To obtain permission to trade under this regime, assembly plants need to maintain a high standard for their accounting personnel and warehouse facilities. For both regimes, because imports are duty-free, firms have great incentive to apply to operate under either of them. Knowing this, China's customs is particularly careful about the use of imported materials by the Chinese plants under either regime. Monthly reports need to be delivered to the customs to show that imported materials are used solely for export processing.

There are several important differences between the two regimes that matter for our model and the interpretation of our empirical results. One is related to the responsibilities of the Chinese plant, and therefore its investments in human capital. Under pure-assembly, the Chinese manager plays a passive role. What she needs to do is mostly routine assembling. Under import-and-assembly, the plant manager is responsible for purchasing materials from abroad and arranging them to be shipped to China. After the shipment, she needs to manage the inventory, and more importantly, maintain the warehouse facilities and accounting procedures according to the government's requirements. A second difference is about the ownership of materials. Under pure-assembly, the Chinese plant has no ownership of materials and her outside option is relatively low. Under import-and-assembly, the plant owns the materials, and can use the materials for multiple foreign clients. Her outside option is therefore relatively high. The third difference has to do with the approval standards. Applications for operating a plant under import-and-assembly is generally more difficult. Plants are required to make investments in warehouse facilities and inventory and accounting systems (Feenstra and Hanson, 2005). The reason is that import-and-assembly plants are allowed to use domestic inputs together with imported materials for export-processing. Value-added taxes need to be paid for the domestically-sourced inputs, which are to be totally rebated if all of these inputs are used for exports. In short, transition from one regime to another is costly.

3 Theoretical Framework

3.1 Technology

To guide our empirical analysis, we present an extension of the North-South trade model with heterogeneous firms by Antràs and Helpman (2004), which is built on the property-rights framework of Grossman and Hart (1986). Our discussion will focus on the part that we extend. Interested

[3] Readers are referred to Feenstra and Hanson (2005) for a more detailed description about the two regulatory regimes.

readers are referred to the original paper for more details. Consider an environment in which all consumers have the same constant elasticity-of-substitution preferences. A firm that produces a brand of a differentiated product faces the following demand function

$$q = Dp^{-\frac{1}{1-\alpha}}, \, 0 < \alpha < 1$$

where p and q stand for price and quantity, respectively; D measures the demand level for the differentiated products in the brand's sector; and α is a parameter that determines the demand elasticity, which is $1/(1-\alpha) > 1$.[4] This demand function implies the following firm revenue

$$R = D^{1-\alpha} q^{\alpha}.$$

The output is produced with inputs invested by the final-good producer (H) in the North and the assembly plant (A) in the South non-cooperatively. Specifically, final goods are produced with three inputs, component activities m, assembly activities a and headquarter services h, according to the following Cobb-Douglas production function:[5]

$$q = \theta \left(\frac{m}{\eta^m} \right)^{\eta^m} \left(\frac{a}{\eta^a} \right)^{\eta^a} \left(\frac{h}{\eta^h} \right)^{\eta^h}, \tag{1}$$

where θ is firm productivity, $1 < \eta^m < 0$, $1 < \eta^a < 0$ and $\eta^h = 1 - \eta^m - \eta^a$. All $\eta's$ are sector-specific parameters. A higher value of η^k implies a more intensive use of factor k. In the context of export processing, a is always chosen by the assembly plant (A) in the South, while h is always chosen by the final-good producer (H) in the North. The unit cost for h is w^N, while that for a is $w^S < w^N$. Depending on the trade regime under which the production unit operates, either A or H, but not together, can invest in component search. Under pure-assembly, H invests in both headquarter activities (h) and component search (m), while A only invests in assembly activities (a). The unit cost of component search is λ^N. Under import-and-assembly, H invests in h, while A invests in both a and m. The unit cost of component search is λ^S. For the moment, we do not make any assumptions about $\lambda' s$.

To better match our empirical analysis, we limit our analysis on H's decisions between foreign outsourcing and foreign vertical integration (i.e., FDI), and ignore all domestic sourcing modes.

[4] As in Antràs and Helpman (2004), the utility function that delivers such a demand function for a firm is

$$U = q_0 + \frac{1}{\mu} \sum_{j=1}^{J} \left[\int_{i \in \Omega} q_j(i) \, di \right]^{\frac{\mu}{\alpha}},$$

where q_0 is consumption of a homogenous good. j is an index representing a differentiated product, i is an index representing a particular brand, μ is a parameter that determines the elasticity of substitution between different differentiated products (i.e., $1/(1-\mu)$). $1/(1-\mu)$ is assumed to be $1/(1-\alpha)$ such that brands within a sector are more substitutable than those between sectors.

[5] One can think of a, m and h as quality-adjusted effect units of inputs, with all quantities normalized to 1.

Irrespective of the trade regime, the components m are always purchased and shipped from outside A's location. This is exactly what the Chinese government requires assembly plants to do for export processing. To fix idea, we summarize the four possible organizational and production modes as follows:

Table 1. Export-Processing Production Modes

	Organizational Form	
Input Control	V (Vertical Integration)	O (Outsourcing)
N (Pure-Assembly)	(N,V)	(N,O)
S (Import-and-Assembly)	(S,V)	(S,O)

The foreign client H can choose to source assembly tasks either under the pure-assembly regime or under the import-and-assembly regime. Within each regime, she can choose to outsource to the assembly plant, or integrate with it. For instance, under production mode (N, V), a foreign-owned affiliate in the South receives components m from the headquarter, and assembles them into finished products for the headquarter in the North.

The final-good producer H needs to pay a number of fixed costs for production. First, she has to pay a fixed cost to enter the market. After paying the fixed cost, she observes the productivity θ for its production unit. Then she decides to exit the market if the expected profits of the production unit are negative. Conditional on continuation, she chooses which trade regime to assemble inputs into final products, and pays different fixed cost accordingly. Under each trade regime, it then pays another fixed cost, which differ across organizational forms (integration or outsourcing). We will discuss the fixed costs, particularly the ranking of them, in more detail below.

Because no enforceable contracts can be signed ex ante, H in the North and A in the South would bargain over the division of surplus from the relationship after investments by both parties are sunk.[6] Following the property-rights approach, we assume that bargaining takes place under both outsourcing and integration. As in Antràs and Helpman (2004), we model the bargaining process as a generalized Nash bargaining game, with a constant fraction $\beta \in (0, 1)$ representing the bargaining power of H, and with $1 - \beta$ being the bargaining power of A.[7] While this bargaining power is fixed, the outside options of each party, and thus the distribution of ex-post surplus between the two parties, are sensitive to the mode of production (i.e. both the trade regime and the organizational form). The relationship between the distribution of surplus and production modes will be discussed in detail below.

[6] For a discussion for the foundation of incomplete contracts, readers are referred to Antràs and Helpman (2004).

[7] One can of course solve the optimal bargaining power of the headquarter, β, which maximizes the ex ante joint-profit for the relationship. Below, we will solve for the joint-profit-maximizing β^*, and compare β's of different trade regimes and production modes with the benchmark β^*.

3.1.1 Timing of Events

Figure 1 describes the timing of events. At t_0, a potential final-good producer H pays a fixed cost to enter the market and draw its productivity. At t_1, H decides which of the four production modes, $\{NV, NO, SV, SO\}$ to adopt. Then at t_2, H randomly chooses an assembly plant A in the corresponding regime in the South. Anticipating events in later periods, both H and A undertake non-contractible investments in a, h and m, according to the production modes. In particular, who invests in activities in component search (m) depends on whether the trade regime is pure-assembly or import-and-assembly. At t_3, intermediate inputs a and h are produced by H and A, respectively. The quality of the intermediate inputs becomes common knowledge. At t_4, H and A bargain over the division of surplus in a Nash bargaining game. If they agree to continue the relationship, components are shipped from abroad to A, which are then assembled with a to produce finished products. At t_5, the finished products are exported to H in the North for final processing. The final goods market clears in the North.

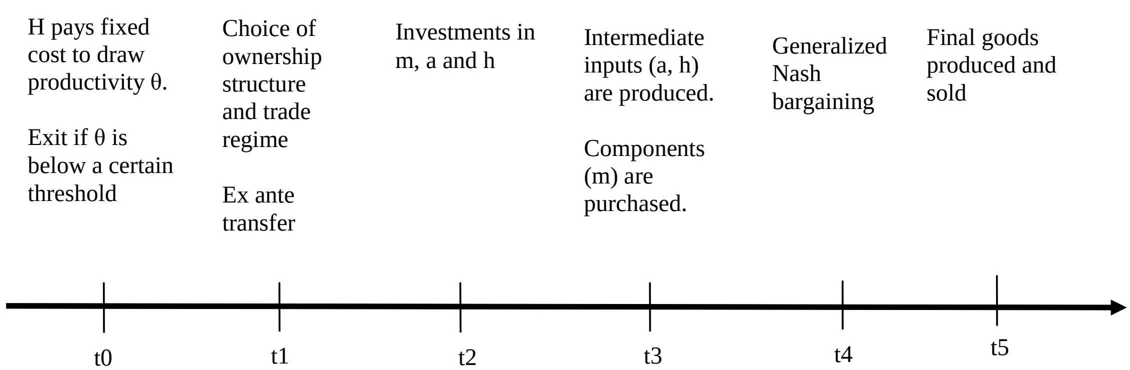

Figure 1: Timing of Events

3.2 Equilibrium

In this section, we solve the model backward for the subgame-perfect equilibrium for a given firm, taking sector-level variables as given. The goal is to derive a number of testable hypotheses related to the prevalence of intrafirm trade across sectors that are specific to export processing in China.[8]

With the production function specified in (1), revenue of the joint production unit between the

[8]Similar to Antràs and Helpman (2004), we do not endogenize equilibrium factor prices. For general equilibrium analysis of this type of model, readers are referred to Antràs (2003).

final-good producer and the assembly plant is

$$R(m,a,h) = D^{1-\alpha}\theta^{\alpha}\left(\frac{m}{\eta^m}\right)^{\alpha\eta^m}\left(\frac{a}{\eta^a}\right)^{\alpha\eta^a}\left(\frac{h}{\eta^h}\right)^{\alpha\eta^h}.$$

At the time of bargaining, the outside options of each party and therefore the ex-post surplus from the relationship are sensitive to the organizational form and the trade regime. As such, their de-facto shares of surplus for each firm are also different. We now analyze the distribution rules of surplus for different organizational arrangements under the two trade regimes, respectively.

3.2.1 Pure-Assembly

Distribution of Surplus in Different Organizational Forms Under pure-assembly, H has control rights and ownership of the components. In addition, if H integrates with A, the latter has no asset ownership. Thus, if inputs of each party are specifically tailored to another party, A's outside option is 0 at the bargaining stage of the game (t_4).[9]

Vertical integration gives H the right to fire the manager A and seize her relationship-specific inputs. If bargaining breaks down, H uses these inputs to assemble the components into finished products, which are then shipped to the North for final-good production using the headquarter inputs h. Following Antràs and Helpman (2004), we make an intuitive assumption that after firing A, H can complete only a fraction $\delta \in (0,1)$ of the original output.[10] A justification is that A has invested in activities that are specific to H. Without A, production is less productive. Thus, the outside option of H equals a discounted revenue $\delta^{\alpha}R < R$. That is, the ex post surplus from the relationship is $(1-\delta^{\alpha})R$. H's expected payoff then includes a fixed share of the surplus and her outside option, which equals $[\beta(1-\delta^{\alpha})+\delta^{\alpha}]R$. Let us denote H's ex-post effective share of the joint revenue by $\beta_{NV} = [\beta(1-\delta^{\alpha})+\delta^{\alpha}]$, and that of A by $(1-\beta_{NV})$.

Now consider outsourcing under pure-assembly. H owns and controls the use of the components (m). Since A's investments are tailored specifically to H, when the two independent parties fail to reach an agreement at the bargaining stage, A obtains 0 income outside the relationship. Without asset ownership, H can no longer seize A's assets as she can in an integrated firm. If H's investments are completely specific to A, H's outside option is also 0.[11] Then the ex-post surplus of the relationship becomes R. H's expected payoff then includes a fixed share of the surplus and her

[9] If inputs are only partially specific to the relationship, A's outside options need not be 0. This assumption is to simplify analysis, and that the main insights of the paper do not rely on the assumption of complete specificity.

[10] This $(1-\delta)$ fraction loss can be considered as quantity (or quality) lost.

[11] One may argue that ownership of components allows H to switch to an outside plant in the South for assembly production when bargaining breaks down, and thus H's outside options can be positive. In particular, if A's investments are not very specific to the relationship, the efficiency loss of switching to an outside plant is small. As such, ownership of components can potentially serve as a mechanism to alleviate the hold up by the assembly plant. We leave this for future research.

outside option, which equals βR. Let us denote H's ex-post effective share of the joint revenue by $\beta_{NO} = \beta$, and that of A by $(1 - \beta_{NO})$. Important for our later analysis, we have

$$\beta_{NV} = [\beta (1 - \delta^{\alpha}) + \delta^{\alpha}] > \beta_{NO} = \beta.$$

Firm Profits under Pure-Assembly Under pure-assembly, H invests in both component search and headquarter services. Recall that the cost of component search is λ^N. Since investments are not contractible ex ante, anticipating ex-post bargaining at t_4, H maximizes her expected operating profits as:

$$\max_{m,h} \beta_{Nl} R (m, a, h) - \lambda^N m - w^N h,$$

Under pure assembly, A's maximization problem is

$$\max_{a} (1 - \beta_{Nl}) R (m, a, h) - w^S a.$$

Solving these two problems gives the joint operating profit function as (see appendix):

$$\pi_{Nl} (D, \eta^a) = D \Theta \psi_{Nl} - w^N \phi_{Nl},$$

where $l \in \{V, O\}$, $\Theta = \theta^{\frac{\alpha}{1-\alpha}}$, ϕ_{Nl} is the fixed cost associated with organizational mode l under pure-assembly, and importantly

$$\psi_{Nl} = \frac{1 - \alpha \left[\beta_{Nl} \eta^h + \beta_{Nl} \eta^m + (1 - \beta_{Nl}) \eta^a \right]}{\left[\frac{1}{\alpha} \left(\frac{w^N}{\beta_{Nl}} \right)^{\eta^h} \left(\frac{w^S}{1 - \beta_{Nl}} \right)^{\eta^a} \left(\frac{\lambda^N}{\beta_{Nl}} \right)^{\eta^m} \right]^{\frac{\alpha}{1-\alpha}}}.$$

As in Antràs and Helpman (2004), β_{Nl} is fixed for each organizational structure and cannot be chosen. However, to explain H's decision between vertical integration and outsourcing, it is insightful to derive the optimal level of bargaining power β_N^* that maximizes joint surplus. Solving $\frac{d\psi_{Nl}}{d\beta_{Nl}} = 0$ gives $\beta_N^* \left(\eta^h \right)$, with $\frac{\partial \beta_N^*}{\partial \eta^h} > 0 \; \forall \; \eta^h \in [0, 1]$ (see appendix for details). This property of $\beta_N^* \left(\eta^h \right)$ implies that in an assembly-intensive sector (with high η^a and low η^h), $\beta_{NV} > \beta_{NO} > \beta_N^* \left(\eta^h_{low} \right)$ and thus $\psi_{NO} > \psi_{NV}$, for a given component intensity. In a headquarter-intensive sector, $\beta_N^* \left(\eta^a_{high} \right) > \beta_{NV} > \beta_{NO}$, so that $\psi_{NV} > \psi_{NO}$. If the fixed costs are identical for both organizational forms, all firms regardless of productivity, would choose outsourcing in an assembly-intensive sector and integration in a headquarter-intensive sector. As is fully explained in Antràs (2003), the intuition is that when production becomes more headquarter-intensive, it is profit-maximizing to give the headquarter more incentive to invest in non-contractible headquarter services, which are important for production. The analysis will be more interesting and relevant if fixed costs vary across trade regimes, which will be discussed formally after we discuss the case for import-and-assembly.

3.2.2 Import-and-Assembly

Distribution of Surplus in Different Organizational Forms We now turn to analyzing the ex-post distribution of joint surplus under import-and-assembly. To this end, we follow Feenstra and Hanson (2005) to assume that if A invests in component search activities, she acquires expertise and develops a business network that allows her to serve as a potential partner for another final-good producer in the North. As such, unlike in pure-assembly, A is able to capitalize her experience and obtain a positive outside option if bargaining breaks down. For simplicity, we assume that A's outside option is equal to a fraction of the original firm revenue, $\gamma R < R$.

If H chooses to vertically integrate with the assembly plant, upon separation, H can always seize A's inputs by firing her and complete assembly production with an outside plant. There will be efficiency loss because A has invested in customized inputs and is more productive than an outside manager, all else equal. H's outside option, similar to the integration mode under pure-assembly, is assumed to be $\delta^{\alpha} R < R$. Under these circumstances, with the assumption that $\gamma + \delta^{\alpha} < 1$, the joint surplus from the relationship is $(1 - \gamma - \delta^{\alpha}) R$. H expects to receive her outside option plus a fixed share of the surplus, which equals $\beta_{SV} R = [\beta(1 - \gamma - \delta^{\alpha}) + \delta^{\alpha}] R$. A expects to receive her outside option plus a fixed share of the surplus, which equals $(1 - \beta_{SV}) R$. Compared to the situation under pure-assembly, A now obtains a larger de-facto bargaining power because of her experience in component search which is valuable outside the relationship.

If H chooses to outsource to the assembly plant in the South, she has no ownership of either A's assets or components. Thus, her outside option equals 0. On the other hand, if A has ownership of the assembly plant, and controls and owns the components, her outside option is positive. Without access to the foreign market and the headquarter inputs, A cannot complete the final-good production. Nevertheless, her expertise and business network acquired during component search can be capitalized outside the relationship. Thus, A's outside option, like the situation for integration under import-and-assembly, is γR. The outside options of the two parties imply that the surplus from the relationship equals $(1 - \gamma) R$. H's expected payoff equals her fixed share of the surplus plus her outside option, which equals $\beta_{SO} R = \beta(1 - \gamma) R$, while A's expected payoff is $(1 - \beta_{SO})$ of the revenue. To summarize, we have the following de-facto share of revenue between the two parties:

$$\beta_{SV} = [\beta(1 - \gamma - \delta^{\alpha}) + \delta^{\alpha}] > \beta_{SO} = \beta(1 - \gamma).$$

Firm Profits under Import-and-Assembly Under import-and-assembly, H invests only in headquarter activities. Recall that the cost of component search is λ^{S}. Since investments are not contractible ex ante, anticipating ex post bargaining, H maximizes her expected operating profits as:

$$\max_{h} \beta R(m, a, h) - w^{N} h$$

A's maximization problem is

$$\max_{a,m} (1-\beta) R(m,a,h) - \lambda^S m - w^S a$$

Solving the two maximization problems gives the joint operating profit function as (see appendix):

$$\pi_{Sl}\left(D,\eta^h\right) = D\Theta\psi_{Sl} - w^N\phi_{Sl},$$

where $l \in \{V,O\}$, $\Theta = \theta^{\frac{\alpha}{1-\alpha}}$ and

$$\psi_{Sl} = \frac{1-\alpha\left[\beta_{Sl}\eta^h + (1-\beta_{Sl})\left(1-\eta^h\right)\right]}{\left[\frac{1}{\alpha}\left(\frac{w^N}{\beta_{Sl}}\right)^{\eta^h}\left(\frac{w^S}{1-\beta_{Sl}}\right)^{\eta^a}\left(\frac{\lambda^S}{1-\beta_{Sl}}\right)^{\eta^m}\right]^{\frac{\alpha}{1-\alpha}}}$$

It is again insightful to derive the joint-profit maximizing $\beta_S^*\left(\eta^h\right)$. Solving $\frac{d\psi_{Sl}}{d\beta_{Sl}} = 0$ gives $\beta_S^*\left(\eta^h\right)$, with $\frac{\partial\beta_S^*}{\partial\eta^h} > 0 \;\forall\; \eta^h \in [0,1]$ (see appendix for details). Similar to the analysis for pure-assembly above, this property of $\beta_S^*\left(\eta^h\right)$ implies that for a given component intensity, if the fixed costs are the same for two organizational forms, all firms regardless of productivity, would choose outsourcing in an assembly-intensive sector, and integration in a headquarter-intensive sector. The rationale is again that the final-good producer should be given more investment incentive through integration when her inputs are more important for production. The predictions will be different if fixed costs differ across organization forms.

3.2.3 Choosing Optimal Production Modes

If all fixed costs are identical, the model predictions are simple: all final-good producers outsource in assembly-intensive sectors, and integrate in headquarter-intensive sectors. However, we observe different organizational forms across sectors from the data. More importantly, in practice, different organizational forms are associated with different costs. It is important to analyze the situations when fixed costs of production vary across organizational forms and trade regimes.

First, we assume that each firm has to pay an identical fixed cost of entry ϕ (in terms of North's labor). Conditional on productivity that is high enough to guarantee non-negative operating profits, a firm chooses trade regime (N or S) and organizational form (V or O) to source its assembly work. We denote by f_k the fixed costs for organizational form k, where $k \in \{V,O\}$. The ranking of f_k is non-trivial. On the one hand, more management effort is needed to monitor overseas employees in an integrated firm. On the other hand, there may exist economies of scope over managerial activities under vertical integration. Following Antràs and Helpman (2004), we assume that managerial overload from managing overseas employees offsets the cost advantage arising from the economies of scope of these activities (i.e., $f_V > f_O$).

We denote by g_l the fixed costs for operations under trade regime l , where $l \in \{N,S\}$. It is intuitive to consider a higher fixed cost for pure-assembly than for import-and-assembly (i.e., $g_N > g_S$). Setting up a logistic network to transport components from overseas suppliers to the assembly plant is costly. Moreover, we assume that overhead costs of transporting tangible goods are higher than those associated with managing a subsidiary (i.e., $g_N > f_V$) Denoting the fixed costs of production mode kl by $\phi_{kl} = f_k + g_l + \phi$, we have the following ranking of fixed costs:[12]

$$\phi_{NV} > \phi_{NO} > \phi_{SV} > \phi_{SO}. \tag{2}$$

Going back to t_1 before each party making non-contractible investments, conditioning on staying in the market, H chooses the production mode to maximize expected operating profits as

$$\pi^* \left(D, \eta^a, \eta^h\right) = \max_{k \in \{N,S\}, l \in \{V,O\}} \pi_{kl} \left(D, \eta^a, \eta^h\right).$$

Recall that through asset ownership, vertical integration always enhances the effective share of surplus in both regimes (i.e., $\beta_{NV} > \beta_{NO}$ and $\beta_{SV} > \beta_{SO}$). However, to rank these shares across trade regimes is also non-trivial. If firing the manager is very costly (low δ^α) or if component ownership can substantially enhance the owner's outside option (high γ), $\beta_{NO} > \beta_{SV}$. In export processing, it is natural to think that the plant's manager is important for managing the plant, and component ownership is an important determinant of the owner's outside option. Based on this argument, we thus focus on the following ranking of $\beta's$ as our benchmark case:

$$\beta_{NV} > \beta_{NO} > \beta_{SV} > \beta_{SO}. \tag{3}$$

Under import-and-assembly, $\beta_{SV} > \beta_{SO} > \beta_S^* \left(\eta^h\right)$ for an assembly-intensive sector, which implies $\psi_{SO} > \psi_{SV}$. Similarly, under pure-assembly, $\beta_{NV} > \beta_{NV} > \beta_N^* \left(\eta^h\right)$ for an assembly-intensive sector, which implies $\psi_{NO} > \psi_{NV}$. Together with the ranking of fixed costs specified in (2), outsourcing is the preferred organizational mode in each regime when assembly intensity is high, because non-integration provides the plant's manager with a larger incentive to invest in assembly activities. After choosing the optimal organizational form, the final-good producer then compares profits associated with the two trade regimes. Given a higher fixed cost for integration under pure-assembly than under import-and-assembly (i.e., $\phi_{NO} > \phi_{SO}$), the optimal choice of trade regime can only be determined by comparing ψ_{NO} and ψ_{SO}. The comparison depends not only on the simple fact that $\beta_{NO} > \beta_{SO}$, but also on the endogenous investment levels by each party.

[12] We assume that the total fixed costs for each production mode are the sum of various fixed costs. One can argue that economies of scope can arise from producing in an integrated firm under pure-assembly, and that $\phi_{NV} < \phi_{SV}$ and $\phi_{NV} < \phi_{NO}$. To simplify analysis, we do not explore these possibilities in this paper.

For simplicity, let us consider a constant component intensity $\overline{\eta}^m$. To have $\psi_{Nl} > \psi_{Sl}$ for $l \in \{O, V\}$, the following inequality needs to hold:

$$\left(\frac{\lambda^N}{\lambda^S}\right)^{\eta^m} \leq \frac{\mu\left(\beta_{Nl}, \eta^h\right)}{\zeta\left(\beta_{Sl}, \eta^h\right)}, \tag{4}$$

where $\mu\left(\xi, \eta^h\right) = \left[1 - \alpha\left(\xi\eta^h + \xi\eta^m + (1-\xi)\left(1 - \eta^h - \eta^m\right)\right)\right]^{\frac{1-\alpha}{\alpha}} \xi^{\eta^h + \eta^m} (1-\xi)^{1-\eta^h-\eta^m}$ and $\zeta\left(\xi, \eta^h\right) = \left[1 - \alpha\left(\xi\eta^h + (1-\xi)\left(1-\eta^h\right)\right)\right]^{\frac{1-\alpha}{\alpha}} (1-\xi)^{1-\eta^h} \xi^{\eta^h}$.

Notice that both μ and ζ are non-monotonic in ξ for low value of η^h. In particular, in an assembly-intensive sector (i.e., when η^h is small), ζ cuts μ from above at $\xi > 1/2$, after which both ζ cuts μ are decreasing in ξ. Thus, inequality (4) is more likely to hold if the final-good producer commands a bigger cost advantage over component purchases (i.e., λ^N/λ^S is smaller). Otherwise, if the assembly plant has access to cheaper components (i.e. $\lambda^S < \lambda^N$), which is likely for assembly plants in China, the bargaining power of H under pure-assembly outsourcing needs to be significantly bigger than that under import-assembly outsourcing (i.e., $\beta_{NO} >> \beta_{SO}$) for inequality (4) to hold. This is likely to be the case if the outside option of the plant is greatly enhanced with control rights over components (high γ).

On the other hand, in a headquarter-intensive sector, (i.e., η^h is large), both μ and ζ are increasing in ξ and $\mu > \zeta$ except when ξ is very small. Thus, inequality (4) always holds for headquarter-intensive sectors for both organizational forms. The rationale is that when headquarter services become more important for production, the benefits (costs) of granting the headquarter more bargaining power increase (decrease). Under the situation that investments in component search are complementary to investments in headquarter services, pure-assembly is the optimal trade regime when headquarter intensity of production is high. Control and ownership over the components give the final-good producer extra incentive to invest in headquarter services under pure-assembly.

To summarize, in an assembly-intensive sector where outsourcing is always the preferred organizational form, we have

$$\begin{aligned} \psi_{NO} &\geq \psi_{SO} \quad \text{if (4) holds} \\ \psi_{NO} &< \psi_{NO} \quad \text{otherwise} \end{aligned} \tag{5}$$

In a headquarter-intensive sector, both integration and outsourcing can coexist within each trade regime. In particular, because $\psi_{NV} > \psi_{NO}$ and $\psi_{SV} > \psi_{SO}$, the more productive firms choose integration within each regime. Furthermore, with (3), we have

$$\psi_{NV} > \psi_{NO} > \psi_{SV} > \psi_{SO} \tag{6}$$

Let us now examine how fixed costs affect firms' organizational choices in sectors of different headquarter intensities under the two trade regimes. In all sectors, firms with productivity levels that are too low to make positive operating profits simply exit the market (i.e., when $D\Theta\psi_{SO} < w^N\phi_{SO}$). In an assembly-intensive sector, there are always some firms that choose to stay in the market and outsource under import-and-assembly. In fact, if $\psi_{NO} < \psi_{SO}$, that is the only equilibrium production mode since the fixed cost for outsourcing is higher under pure-assembly than import-and-assembly (i.e., $\phi_{NO} > \phi_{SO}$). On the other hand, if $\psi_{NO} \geq \psi_{SO}$ (when (4) holds), firms with high-enough productivity levels have $\psi_{NO} - \psi_{SO} > \frac{\phi_{NO}-\phi_{SO}}{D\Theta}$. These firms would choose to outsource assembly tasks to plants in the South under the pure-assembly regime. As discussed earlier, this is more likely to happen if the headquarter has a significant cost advantage over component purchases (i.e. λ^N is significantly smaller than λ^S). The two situations are illustrated in Figures 2 and 3.

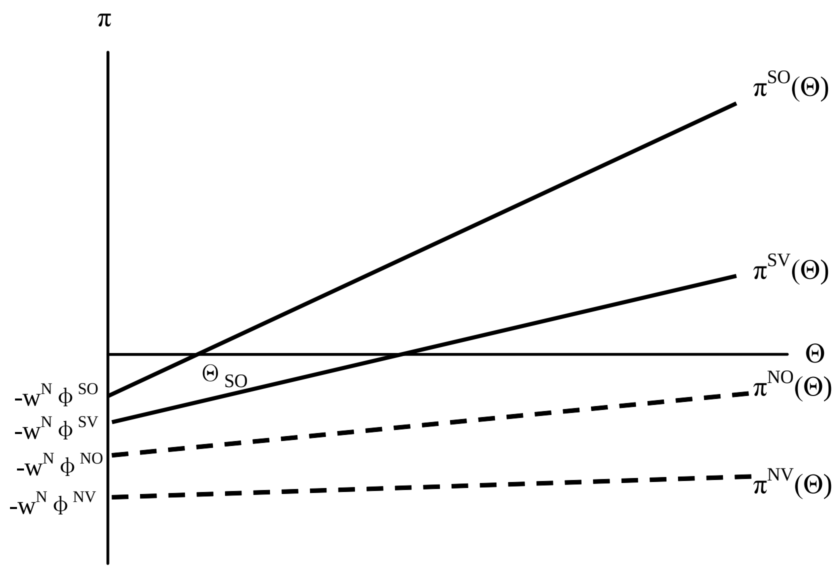

Figure 2: Assembly-intensive sector when $\psi_{NO} < \psi_{SO}$

Let us now turn to a headquarter-intensive sector. With the ranking of fixed costs specified in (2), four production modes can exist in a headquarter-intensive sector, as depicted in Figure 4. In particular, there are four productivity cutoffs that determine the ranges of the heterogenous firms that operate in different production modes. Firms with productivity parameter $\theta^{\frac{\alpha}{1-\alpha}}$ below Θ_{SO} exit, those with productivity parameter between Θ_{SO} and Θ_{SV} outsource under import-and-assembly, those with productivity parameter between Θ_{SV} and Θ_{NO} integrate under import-and-assembly, those with productivity parameter between Θ_{NO} and Θ_{NV} outsource under pure-assembly, and finally those with productivity parameter above Θ_{NV} integrate under pure-assembly.

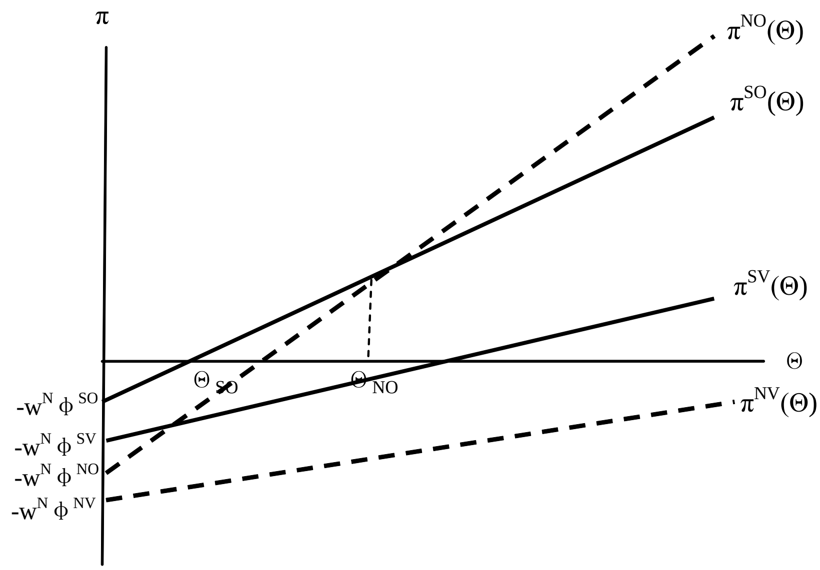

Figure 3: Assembly-intensive sector when $\psi_{NO} \geq \psi_{SO}$

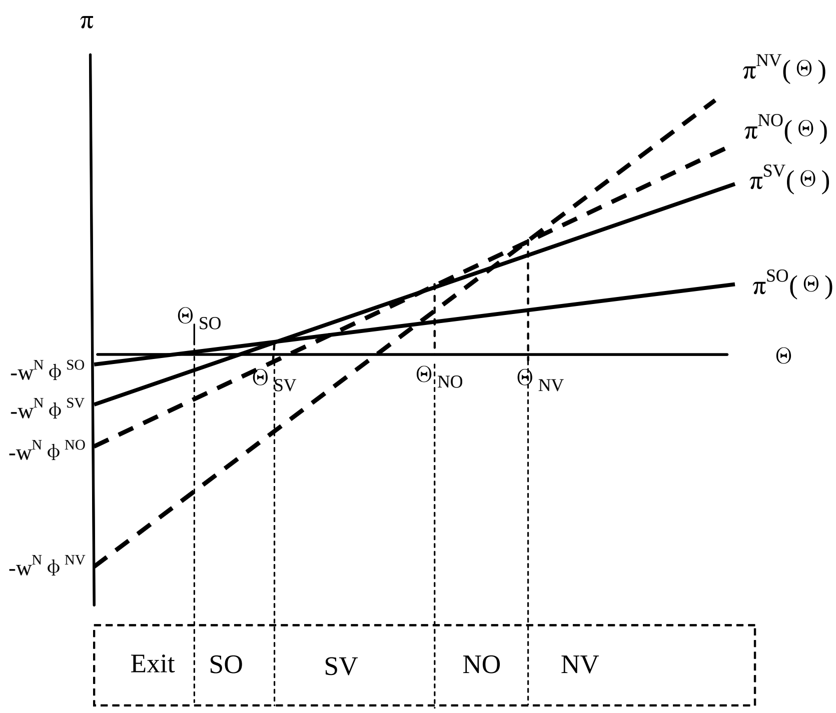

Figure 4: Headquarter-intensive Sector

These cutoffs can be solved using a set of indifference conditions (e.g. $\pi_{SV}\left(\Theta_{NO}, D, \eta^a, \eta^h\right) = \pi_{NO}\left(\Theta_{NO}, D, \eta^a, \eta^h\right)$) as follows:

$$\begin{aligned}
\Theta_{SO} &= \frac{B\phi_{SO}}{\psi_{SO}} \\
\Theta_{SV} &= \frac{B\left(\phi_{SV} - \phi_{SO}\right)}{\psi_{SV} - \psi_{SO}} \\
\Theta_{NO} &= \frac{B\left(\phi_{NO} - \phi_{SV}\right)}{\psi_{NO} - \psi_{SV}} \\
\Theta_{NV} &= \frac{B\left(\phi_{NV} - \phi_{NO}\right)}{\psi_{NV} - \psi_{NO}},
\end{aligned} \tag{7}$$

where $B = w_N/D$. Notice that this is the benchmark case when all four production modes coexist. Besides integration under pure-assembly, which must exist in a headquarter-intensive sector in theory, some of the productivity cutoffs and therefore production modes may not exist in a headquarter-intensive sector. It is however highly unlikely that integration under pure-assembly is the only production mode.

To analyze the impact of headquarter intensity on the prevalence of intrafirm trade, we first derive a closed-form expression for the fraction of the final-good producers choosing each production mode in a sector. In an assembly-intensive sector, no firms choose integration and the fraction of intrafirm trade is simply 0. It is worth emphasizing that when $\psi_{NO} < \psi_{SO}$, import-and-assembly outsourcing is the only production mode.

In a headquarter-intensive sector, all four production modes can coexist. Let the cumulative distribution function of firm productivity be $G\left(\Theta\right)$. To obtain closed-form expressions for the share of each production mode in a sector, we follow Helpman, Melitz and Yeaple (2004) to assume that Θ is distributed Pareto with shape parameters κ, so that

$$G\left(\Theta\right) = 1 - \left(\frac{\Theta_{\min}}{\Theta}\right)^{\kappa} \quad \text{for } \kappa > 2 \text{ and } \Theta \geq \Theta_{\min} > 0$$

To gauge our empirical analyses that examine the impact of headquarter intensity in each trade regime separately, we express explicitly the fraction of firms choosing production mode SO, SV,

NO, NV in a headquarter-intensive sector respectively as follows:

$$\begin{aligned} S_{SO} &= 1-\left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}, \\ S_{SV} &= \left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}-\left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa}, \\ S_{NO} &= \left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa}-\left(\frac{\Theta_{SO}}{\Theta_{NV}}\right)^{\kappa}, \\ S_{NV} &= \left(\frac{\Theta_{SO}}{\Theta_{NV}}\right)^{\kappa}. \end{aligned} \tag{8}$$

To analyze the impact of headquarter intensity on the prevalence of intrafirm trade in each trade regime, consider an increase in headquarter intensity η^h in the case where all four production modes exist. As integration is favored relative to outsourcing under each trade regime, the ratio ψ_{kV}/ψ_{kO} for $k=N,S$ is higher in sectors with higher values of η^h. Thus, Θ_{SO}/Θ_{SV} increases with η^h, and the share of import-and-assembly outsourcing firms S_{SO} in total export-processing firms decreases with headquarter intensity.[13] While the impact of a higher η^h on the share of import-and-assembly integrated firms S_{SV} in total export-processing firms is ambiguous, we can still determine the effects on the fraction of integrated firms within the import-and-assembly regime. In particular, the fraction of integrated firms within import-and-assembly is $\frac{S_{SV}}{S_{SO}+S_{SV}}=1-\left[1-\left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}\right]/\left[1-\left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa}\right]$. Since Θ_{SV}/Θ_{NO} increases with ψ_{NO}/ψ_{SV}, which in turn increases with η^h, as long as both organizational forms exist under import-and-assembly, the share of integrated firms within the regime is higher in sectors with higher values of η^h.

Similarly, given that ψ_{NO}/ψ_{SV} increases with η^h, the share of firms operating under pure-assembly in total export-processing firms is higher in the more headquarter-intensive sectors.[14] However, the impact of η^h on the composition of firms across the two organizational forms within the pure-assembly regime is ambiguous. According to equation (8), the fraction of integrated firms is $\frac{S_{NV}}{S_{NV}+S_{NO}}=\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{\kappa}$.[15] Figuratively, consider the hypothetical exercise that a sector becomes more headquarter-intensive. On the one hand, some firms who used to integrate with assembly plants under import-and-assembly would switch to outsourcing under pure-assembly. On the other hand, some firms who used to outsource under pure-assembly now integrate with the assembly plants within the same regime. The composition of the two organizational forms under pure-assembly at the end depends on which productivity cutoff is more responsive to the headquarter-intensity change.

Figure 5 summarizes the impact of an increase in η^h on the productivity cutoffs and therefore

[13] $\frac{\Theta_{SO}}{\Theta_{SV}}=\left(\frac{\psi_{SV}}{\psi_{SO}}-1\right)\frac{\phi_{SO}}{\phi_{SV}-\phi_{SO}}$.

[14] This can be shown by the fact that $\frac{S_{NV}+S_{NO}}{S_{SV}+S_{SO}}=\frac{\phi_{SO}\left(\frac{\psi_{NO}}{\psi_{SO}}-\frac{\psi_{SV}}{\psi_{SO}}\right)}{(\phi_{NO}-\phi_{SV})}$.

[15] The ratio $\frac{\Theta_{NO}}{\Theta_{NV}}=\frac{\phi_{NO}-\phi_{SV}}{\phi_{NV}-\phi_{NO}}\frac{1-\frac{\psi_{NO}}{\psi_{NV}}}{\frac{\psi_{NO}}{\psi_{NV}}-\frac{\psi_{SV}}{\psi_{NV}}}$ may increase or decrease with η^h.

the shares of intrafirm trade within each regime. The dashed lines represent indeterminacy of the new cutoffs as a result of a higher η^h.

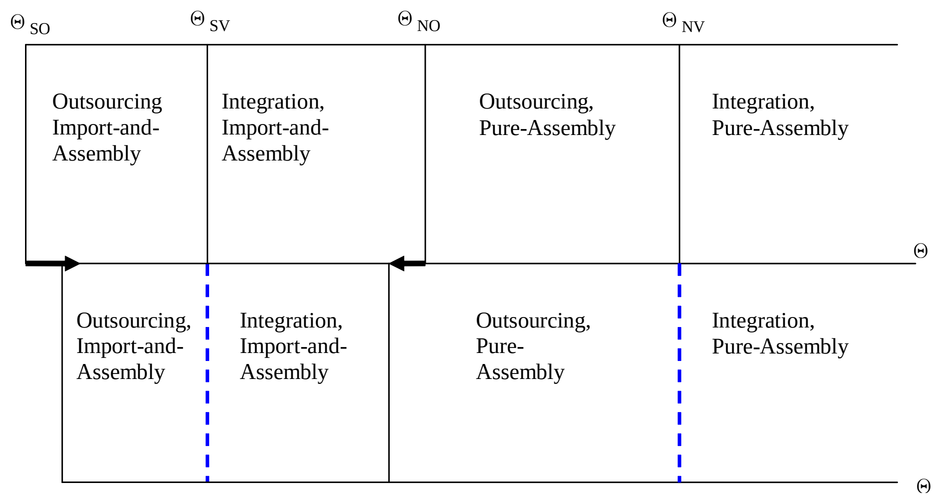

Figure 5: The impact of an increase in headquarter intensity on the productivity cutoffs

With the possibility of the absence of pure-assembly trade in some assembly-intensive sectors, we examine the following hypothesis in the rest of the paper.

Hypothesis 1: Headquarter Intensity and the Prevalence of Intrafirm Trade Given the ranking of fixed costs of production as specified in (2), the share of intrafirm exports is higher in the more headquarter-intensive sectors under the import-and-assembly regime. Such relationship may not be observed under the pure-assembly regime.

The second hypothesis of the paper has to do with productivity dispersion. Although the prediction on the relationship between headquarter intensity and the prevalence of intrafirm trade is ambiguous for the pure-assembly regime, the model predicts that only the most productive firms choose pure-assembly in a headquarter-intensive sector. As such, if the distribution of firm productivity is more skewed towards the highest productivity level in a sector, intrafirm trade should be more prevalent, particularly under the pure-assembly regime.

Hypothesis 2: Productivity Dispersion and the Prevalence of Intrafirm Trade Given the ranking of fixed costs of production as specified in (2), a higher sectoral productivity dispersion is associated with a larger share of intrafirm trade in headquarter-intensive sectors, particularly under the pure-assembly regime. Such relationship is absent in the assembly-intensive sector where integration is never a profit-maximizing organizational mode.

4 Data

To examine the determinants of intrafirm exports from China in different trade regimes, we use trade data from the Customs General Administration of the People's Republic of China. The data report values in US dollars for imports and exports of over 7,000 products in the HS 8-digit classification (example of a product: 61124100 - Women's or girls' swimwear of synthetic fibres, knitted or crocheted), from and to over 200 destinations around the world, by type of enterprise (out of 9 types, e.g. state owned, foreign invested, sino-foreign joint venture), region or city in China where the product was exported from or imported to (out of around 700 locations), customs regime (out of 18 regimes, e.g. process and assembling and process with imported materials). The data also reports quantity, quantity units, customs offices (ports) where the transaction was processed (97 in total), and transportation modes.

Skill, material, capital, capital-equipment and capital-plant intensities are constructed using data from the Bartelsman and Gray (1996) data base for 2002.[16] Following Nunn and Trefler (2008), we use U.S. factor intensities, assuming that they are correlated with the factor intensity of production in other countries. For each 4-digit SIC industry we use information on total capital, capital-equipment, capital-structures (plant), wages of production workers and non-production workers, and total expenditures on materials. Using this information we construct measures of capital intensity denoted K_i/L_i, skill-intensity H_i/L_i, material intensity M_i/L_i, capital-equipment intensity E_i/L_i and capital-plant intensity P_i/L_i. Capital intensity (total capital, capital-equipment and capital-plant) K_i/L_i, E_i/L_i, P_i/L_i is measured as the natural log of the corresponding capital expenditures divided by all worker wages. Material intensity M_i/L_i is measured as the log of material expenditures divided by workers wages. Skill intensity H_i/L_i is the log of non-production worker wages divided by total worker wages. To check robustness, we construct measures of capital and skill intensity using Chinese plant-level data on capital and workers of different skill levels. These plant-level data are obtained from the Census of Industrial Production for 2004, which was conducted by the Chinese National Bureau of Statistics. Restricted by data availability, we cannot use exactly the same definitions of factor intensities. Capital intensity is measured by the log of the real value of capital divided by the real value of output of each sector. Human capital is the log of the share of high-school graduates in the sectoral workforce.

To capture the contractibility of inputs, we take measures from Nunn (2007), which equal the proportion of an industry's intermediate inputs that are relationship-specific and therefore more susceptible to suffer from potential contracting problems. Because we want a measure that is increasing in the completeness of contracts, we use one minus the fraction of inputs that are relationship-specific (i.e., one minus the fraction of inputs not sold on exchanges and not reference-priced). For the quality of the legal institutions in Chinese provinces, we adopt the measures from Fan et al. (2008). The measures are the weighted averages of i) the ratios of business or economic

[16] We are grateful to Randy Becker from the U.S. Bureau of the Census for providing us with an updated version of the database covering the years 1997-2002.

lawsuit expenditure over provincial GDP (in constant yuan) and ii) economic or business lawsuits concluded by the province's courts as a fraction of cases filed. High values indicate an active and efficient legal system.

We use the measure of industry productivity dispersion from Nunn and Trefler (2008) for 2005. The construction of this measure follows Helpman et al. (2004); using firm sales as a measure of firm productivity, they construct estimates of the dispersion of firm productivity using the standard deviation of firm sales across all firms within an industry. Given the lack of firm-level data, Nunn and Trefler (2008) construct sales of "notional" firms using U.S. export data from the U.S. Department of Commerce. They define an industry as an HS6 product and the sales of a notional firm as the exports of an HS10 good exported from U.S. location l to destination country c. Their measure of productivity dispersion within an industry is the standard deviation of the log of exports of a good from location l to country c.[17] We use the US productivity dispersion measure as the decision on the organizational form is made by the developed country's headquarter. We believe that the measure for the U.S. is a good proxy for productivity dispersion measures in other developed countries. To check robustness, we use the Chinese exports data to construct productivity dispersion measures using the same method. Given the highest level of geographical disaggregation of the Chinese data, which is also disaggregated by enterprise type and customs regime, we define sales of "quasi-firms" as exports of an HS6 product by enterprise type, customs regime, from a location in China (out of 700 locations) to a destination country. Our measure of productivity dispersion is the standard deviation of the sales of these "quasi-firms." We also use a measure of productivity dispersion based on the standard deviation of Chinese firms' sales as an alternative. Data on manufacturing firm sales are obtained from the Annual Survey of Industrial Production for 1998-2005, which was conducted by the Chinese National Bureau of Statistics.

5 Estimation Results

5.1 Examining the Effects of Headquarter Intensity

Following the existing empirical literature on the determinants of intrafirm trade, such as Antràs (2003), Yeaple (2006) and Nunn and Trefler (2008), we use skill and capital intensities as our proxies for the importance of headquarter services in production. Furthermore, since we are interested in studying the propensity of integration by multinational firms under the two trade regimes in which the control rights of components are allocated to different parties, we use material intensity as a proxy for the importance of components in production. To test Hypothesis 1, we estimate the following cross-industry regression for each trade regime separately:

$$\frac{X_j^{kV}}{X_j^{kV} + X_j^{kO}} = \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \epsilon_j, \tag{9}$$

[17] We are grateful to Nathan Nunn for sending us the data for the measure of productivity dispersion of US firms.

where j stands for industry, V and O represent vertical integration and outsourcing, respectively. The dependent variable is the share of Chinese exports in industry j under trade regime k that are accounted for by foreign affiliates. We use this ratio as our measure of intra-firm trade based on the assumption that assembly plants under an export-processing regime assemble intermediate inputs into final goods for their foreign owners.[18] For the proxies for headquarter intensity, the first one is H_j/L_j, which is the log of non-production worker wages to total worker wages; the second one is K_j/L_j, which is the log of the real value of capital stock to the total wage bill. Material intensity M_j/L_j is the log of the cost of materials divided by total worker wages.[19]

According to our model, intrafirm trade should account for a larger share of exports in the more headquarter-intensive sectors under the import-and-assembly regime, but not necessarily under pure-assembly. Thus, the predicted signs of γ_H and γ_K are positive for the import-assembly regime.

Estimates of equation (9) for both trade regimes are shown in Table 4. We regress the share of intrafirm exports in total exports on a set of measures of headquarter intensities. A sector is defined as an SIC-87 4-digit category. In columns (1) through (3), we report results for the import-and-assembly regime. The coefficients on skill intensity are positive and statistically significant at the 1% level. The impact is also economically meaningful. These coefficients suggest that a one standard-deviation increase in skill intensity is associated with between 0.116 and 0.131 standard-deviation increases in the share of intrafirm trade, which correspond to 2 to 3 percentage-point increases. These results confirm the main findings by Antràs (2003), Yeaple (2006), Bernard, Jensen, Redding and Schott (2008), Trefler and Nunn (2009), who find a positive relationship between skill intensity and the presence of intrafirm trade across U.S. manufacturing industries. The size of the coefficients are at the same magnitude of those reported by Nunn and Trefler (2008) for the U.S. sectors.

For import-and-assembly exports, the coefficients on capital intensity are negative and even significant, in contrast to the theoretical predictions of existing theories. Similar to a recent work by Nunn and Trefler (2008), we explore the varying degree of relationship specificity of different kinds of physical capital. In Antràs (2003), it is assumed that investments by either party of a trade relationship are completely relationship-specific. If the two parties disagree to continue the relationship, the value of the inputs outside the relationship is 0. However, if capital is partially relationship-specific, its value outside the relationship is positive, and is decreasing with the specificity of the capital. Nunn and Trefler (2008) argue that equipment and machinery tend to be more relationship-specific, while buildings and plants can be resold and reused for the production

[18] One can argue that in practice, a foreign-owned assembly plant can be involved in a production relationship with a foreign firm other than its owner. We are aware of this impecfection of our dependent variable. In China, this type of supply-chain relationships are usually found between two large multinational firms, but rarely found for the small and medium-sized foreign-owned enterprises. For pure-assembly exports, the criticism is invalid as assembly plants always import materials directly from the their headquarters.

[19] We also use total employment of each sector as the denominator of each measure of factory intensity. Our results are insensitive to the use of these alternative measures.

of other goods. Based on this argument, we should expect to find different results for different types of capital. To this end, instead of adding an overall measure of capital intensity, we include equipment-capital and plant-capital (less relationship-specific) intensities separately in the regressions. In column (3), we find that the coefficient is negative and significant only on plant intensity, the kind of capital that is supposed to have a higher outside value. Equipment intensity, on the other hand, is found to be unrelated with trade within multinational firm boundaries.

Let us now turn to pure-assembly. In columns (4) to (6), we find no significant relationship between all measures of headquarter intensity and the share of intrafirm trade across sectors. These results are consistent with our theoretical prediction that the relationship between the prevalence of intrafirm trade and headquarter intensity is ambiguous for pure-assembly exports. With firm heterogeneity, more firms would choose to outsource and vertically integrate under pure-assembly in sectors with higher headquarter intensity. The share of intrafirm trade under pure-assembly, thus, can increase or decrease. The coefficient on capital intensity is barely significant at the 10% level in column (4) when material intensity is not controlled for, and becomes insignificant once material intensity is included as a regressor. In short, we find no relationship between headquarter intensity and the share intrafirm trade under the pure-assembly regime.

In Table 5, we repeat the analogous analyses of Table 4 at the HS 6-digit level. Because our regressors of interest only vary across SIC 4-digit industries, standard errors are clustered at the SIC 4-digit level to take into account the correlation between observations within the same SIC category. We continue to find a significant relationship between the share of intrafirm trade and skill intensity for the import-and-assembly exports (coefficients on skill intensity are statistically significant at the 1% level), consistent with the results in Table 4. No insignificant results are found for the pure-assembly regime.

The regression exercises so far examine shares of exports aggregated across different importing countries within the same sector. The results hide substantial differences across the importing countries, as well as the differences in the relationship between China and these countries, such as distance, institutional and endowment differences. Since our focus is on the sectoral determinants of intrafirm trade, instead of examining the impact of these countries' characteristics on intrafirm trade, we repeat the sectoral analyses in Table 5 using observations of unilateral exports in a HS-6 category to each importing country and controlling for country fixed effects.

Table 6 reports the results. For the import-and-assembly regime (columns (1) to (3)), we find results consistent with the findings in Table 5. Estimates for skill, equipment and plant intensities continue to take the same signs, and all become more statistically significant. These results support the theoretical predictions that a higher intensity of headquarter inputs, particularly those that are more relationship-specific (i.e. equipment capital), increases the share of intrafirm trade under import-and-assembly. A higher material intensity is found to have a significantly negative impact on intrafirm trade share (significant at the 5% level). Although our theoretical prediction does not formally discuss the impact of material intensity on intrafirm trade, we can use the theories in the spirit of control rights to explain the relationship. Under import-assembly, the control rights over materials are allocated to the assembly plant. Since integration effectively grants a bigger share of expected revenue to the headquarter, it weakens the plant's incentive to invest in input-search activities. The distortion effects are bigger in more material-intensive sectors, making integration a less preferred organizational mode.

For pure-assembly (columns (4) to (6)), we also find more statistically significant results compared to analyses when country fixed effects are not controlled for. It is perhaps surprising to find that the coefficient on skill intensity is now negative and statistically significant, implying a negative relationship between headquarter intensity and the share of intrafirm trade. While these results should not be taken as a rejection to existing theories on intrafirm trade, they are consistent with our theoretical prediction that the mass of firms switching from import-and-assembly to pure-assembly outsourcing can be larger than that switching to integration under pure-assembly.

The fact that the regression results at the country-sector level are more significant implies the existence of large heterogeneity across importing countries that affects the headquarters' integration choices. In particular, contracting institutions differ widely across countries, and can affect the use of vertical integration to alleviate the hold-up problems (Antràs and Helpman, 2008). Thus, controlling for country fixed effects takes cross-country differences into account. For this reason, in the remaining empirical analyses, we shall focus on the regressions using exports to each country as units of observations, with country fixed effects always included.

So far, we have been examining exports from China to the rest of the world, regardless of whether the importing countries are developed or not. To obtain a set of empirical results mapping the predictions of a North-South trade model, we should focus on Chinese exports to developed countries. To this end, we conduct regression analyses over samples of low-income countries, high-income countries, and a few selected countries. The results for import-and-assembly are reported in Table 7. We find positive and significant coefficients on skill intensity across all specifications. If we restrict exports to only low-income countries (column (1)), the magnitude of the coefficient (0.170) is bigger than that for high-income countries (0.108). To address the concern that the US-based factor intensity measures do not reflect the intrinsic properties of production, and are specific only to the U.S., we focus on exports only to the U.S. in column (3). Results similar to those in Table 6 are obtained. Importantly, we find a significantly positive relationship between equipment-capital intensity and the share of intrafirm trade. In columns (4) and (5), we focus on exports only to Japan and only to high-income European countries, respectively. We find the same set of significant results as for the U.S., with almost quantitatively identical estimates on factor intensities. There is a concern that many of the foreign-owned plants have their headquarters in Hong Kong, who serve as intermediaries to re-export final products to foreign clients. To address this concern, we exclude exports to Hong Kong in column (6). We continue to obtain the main results. In short, empirical results for Hypothesis 1 are robust to the use of different country samples.

Table 8 reports the regression results for different country samples for the pure-assembly regime. The coefficients on the skill intensity are mostly insignificant. When they are significant, the signs are negative, which suggest less intrafirm trade in sectors with higher values of headquarter intensity. More research is needed to understand this pattern. It is important to emphasize that our model allows such a possibility.

The factor intensity measures we used so far are constructed using data from U.S. manufacturing firms, based on the assumption that ranking of these measures is stable across countries. Although this approach has been adopted by many previous empirical studies,[20] we still attempt to check robustness of our results by using the factor intensity measures constructed using Chinese plant-level data. Due to data limitation, we cannot use exactly the same definitions as the US-based measures. Capital intensity is measured by the log of the average real value of capital divided by the real value of output in each sector. Human capital is the log of the share of high-school graduates in the workforce in each sector. Table 9 reports the regression results using the Chinese-plant-based factor intensity measures. A significantly positive relationship between skill intensity and the share of intrafirm trade is found under import-and-assembly. The result is obtained regardless of whether we use exports aggregated across importing countries in a sector, or disaggregated exports at the country-sector level. The coefficients on capital intensity, however, are significantly negative. For pure-assembly exports, the sign of the coefficient on skill intensity turns negative, and that on capital intensity becomes insignificant.

5.2 Examining the Effects of Productivity Dispersion

Now we explore the effects of firm productivity dispersion, and its interactive effects with headquarter intensity, on the prevalence of intrafirm trade across industries. It is now a well-known fact that firm productivity differs widely within an industry, and exhibit a flat-tail distribution. According to Bernard et al. (2007), the top 10 percent of the exporting firms accounted for 96 percent of all U.S. trade in 2000.

Hypothesis 2 states that the more productive headquarter firms choose to integrate with assembly plants in headquarter-intensive sectors, but not in assembly-intensive sectors. Moreover, the model predicts that the most productive firms choose pure-assembly integration in headquarter-intensive sectors. Thus, we should expect more pronounced effects of productivity dispersion on the share of intrafirm trade under the pure-assembly regime.

We use the standard deviation of firm (log) sales across all firms within an industry in the U.S. $\left(\sigma_j^{\theta}\right)$ as the empirical counterpart of productivity dispersion, and estimate the following equation

[20] The approach of using sector measures constructed using U.S. data originates from Rajan and Zingales (1998). In their study of the differential impacts of countries' financial development on sectoral growth, they use sector measures of dependence on external finance, which are constructed using data of U.S. publicly-listed firms. Subsequent empirical studies on countries' comparative advantage have adopted the same approach. See Romalis (2003), Levchenko (2007), Nunn (2008) and Manova (2007), among others.

to examine Hypothesis 2:

$$\frac{X_j^{kV}}{X_j^{kV}+X_j^{kO}}=\gamma_H\frac{H_j}{L_j}+\gamma_K\frac{K_j}{L_j}+\gamma_M\frac{M_j}{L_j}+\delta_\theta\sigma_j^\theta+\delta_{\theta\eta}\sigma_j^\theta\eta_j+\epsilon_j, \tag{10}$$

where η_j is a measure of one of the factor intensities: skill, capital, equipment or plant intensities. Hypothesis 2 predicts $\delta_\theta > 0$ and $\delta_{\theta\eta} > 0$, particularly for the pure-assembly regime under which the most productive firms operate.

Using the sample of exports to each country at the HS 6-digit level, we report the estimates of equation (10) in Table 10. We include all stand-alone headquarter intensity measures as controls. Because our measure of productivity dispersion is industry specific, we include country fixed effects and cluster the standard errors at the SIC level. Columns (1) through (3) report results for the import-and-assembly regime, while columns (4) through (6) report those for pure-assembly. For pure-assembly, results reported in columns (4) and (6) show that, when skill- or equipment-intensity is interacted with σ_j, we find positive and statistically significant coefficients (at the 1% level) for both the dispersion and the dispersion interaction terms. When we use capital intensity as our measure of η_j, we continue to find a strongly positive coefficient on the interaction term, but not the stand-alone dispersion term. The estimated relationship between productivity dispersion and the share of intrafirm exports is higher in sectors with higher headquarter intensity when skill or capital-equipment are used as the measures of headquarter intensity. In sum, we find evidence supporting Hypothesis 2 for the pure-assembly regime.

For import-and-assembly exports, on the other hand, we find no evidence supporting Hypothesis 2. In particular, while the coefficient on the stand-alone dispersion term is positive when capital and equipment capital intensities are used as our measures of η_j, the coefficients on the interaction term are now negative and statistically significant in columns (5) and (6), which are inconsistent with Hypothesis 2. As a robustness check we restrict the sample to consider only export to the US. The results for this exercise are shown in Table A1 in the appendix. The sign, significance and magnitude of the estimated coefficients are similar to those reported in Table 10.

As further robustness checks we also use two Chinese-based measures of productivity dispersion. The first is similar in construction to the measure based on the dispersion of US exports. We define sales of “quasi-firms" as exports of an HS 6-digit product by enterprise type, customs regime, from a location in China (out of 700 locations) to a destination country. Our measure of productivity dispersion is the standard deviation of the log of the sales of these “quasi-firms." Since a firm may export to more than one country, and in more than one customs regime, we construct an alternative measure by aggregating across export destinations and customs regimes. This alternative measure of dispersion of productivity is the standard deviation of an HS 6-digit product by enterprise type, from a given location in China. The results obtained using this measure (available on request) are similar to those reported in Table 11.

The results using the measure of dispersion based on Chinese exports are reported in Table 11. They are consistent with those obtained with the US-based measure of export dispersion. Again, for import-and-assembly we do not find evidence supporting the theoretical hypothesis, while for pure-assembly the results support the prediction when skill is used to proxy for headquarter intensity. In particular, when using skill as a measure of headquarters intensity, we observe that the estimated relationship between productivity dispersion and the share of trade that is intrafirm is higher in sectors with higher headquarter intensity. When capital-equipment is used to measure headquarter intensity, the coefficient on the interaction term between productivity dispersion and headquarter intensity is positive and statistically significant but the stand-alone coefficient is not statistically significant. In sum, the results using the Chinese measure of dispersion of productivity also provide empirical support for the theoretical prediction for pure-assembly but not for import-and assembly. Furthermore, when we use Chinese manufacturing firm sales to construct our dispersion measures, we find consistent results, which are reported in Table A2 in the appendix. In short, the positive relationship between productivity dispersion and intrafirm trade under pure-assembly are robust to the use of a number of dispersion measures.

The empirical specification imposes a linear restriction on the relationship between productivity dispersion and intrafirm trade. To examine the theoretical model in a more flexible empirical framework, and to identify the cut-off level of headquarter intensity over which productivity dispersion matters, we follow Nunn and Trefler (2007) and consider a regression that allows the relationship between dispersion and intrafirm exports to differ by quintiles of headquarter intensity. We rank our SIC-1987 industries by headquarter intensity measured either by skill, capital or capital-equipment. Then we divide the industries into 5 quintiles of headquarter intensity. The headquarter intensity quintile dummies are defined as $I_{jp}^{\eta} = 1$ if industry j is in quintile p, $p = 1$ being the least headquarters-intensive quintile. We estimate equation (11) below which includes interaction terms between the quintile dummies and the productivity dispersion measure. The equation also includes country fixed effects, headquarter intensity quintile dummies and headquarter intensity controls. The standard errors are clustered at the industry level.

$$\frac{X_j^{kV}}{X_j^{kV} + X_j^{kO}} = d_c + \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \sum_{p=1}^{5} \delta_{\eta p} I_{jp}^{\eta} + \sum_{p=1}^{5} \delta_{\theta \eta p} (\sigma_j^{\theta} * I_{jp}^{\eta}) + \epsilon_j, \quad (11)$$

The results are reported in Table 12. Columns (1) through (5) report results for the import-and-assembly regime, while columns (6) through (10) report those for pure-assembly. The average effect is positive and statistically significant for the pure-assembly regime and is estimated at 0.09 or 0.08 depending on whether we include quintile dummies or not (columns (6) and (7)). This suggests that a one-standard deviation increase in productivity dispersion is associated with an increase in intrafirm exports of about 2 percentage points. The coefficient is not statistically significant for the import-and-assembly regime (columns (1) and (2)).

Next, we let the effect of productivity dispersion vary depending on the headquarter intensity of the industry. Results for pure-assembly (columns (8) to (10)) show that there is a jump in the magnitude of the coefficient at around the 4th quintile. Specifically, the coefficient on the interaction between the quantile dummies and the dispersion measure becomes positive and statistically significant after the 4th quintile when we use capital or capital-equipment to proxy for headquarter intensity and it becomes statistically significant in the 5th quintile of headquarter intensity when it is measured by skill-intensity. This means that for the highest headquarter-intensive industries an increase in productivity dispersion increases the share of intrafirm exports. These results therefore provide support for the theoretical prediction for the pure-assembly regime. This is consistent with the results reported in Table 10. Regarding the import-and-assembly regime, results reported in columns (3) to (5) are inconsistent with the theoretical prediction. This is also consistent with the findings of Table 10.

5.3 Examining the Effects of the Contractibility of Suppliers' Inputs

Antràs and Helpman (2008) relax the assumption that relationship-specific investments are completely non-contractible, and allow for varying degrees of contractibility across inputs and countries. An important prediction is that besides headquarter intensity of inputs, the degree for which the investments in these inputs are contractible are important determinants of vertical integration by multinationals. Holding headquarter intensity constant, an increased contractibility of supplier's inputs, possibly due to an improvement in the legal or property-rights institutions of the supplier's country, can have surprising effects on the propensity for integration. On the one hand, an improvement in the contractibility of inputs implies more tasks being contractible (the "Standard Effect"). Thus, the motives of integrating with the supplier to reduce the hold-up effects are lessened. On the other hand, because more tasks are contractible, the headquarter is less concerned about the distortion effects of integration on the supplier's investment incentives (the "Surprise Effect"). Integration becomes more preferred even in sectors with lower headquarter intensity. If the "Surprise Effect" dominates the "Standard Effect", the share of intrafirm trade increases with the contractibility of inputs. To this end, we investigate the following prediction.

Hypothesis 3: Contractibility of Investments and Intrafirm Trade Given the ranking of fixed costs of production as specified in (2), consider an improvement in the contractibility of the assembly plant's inputs.

(1) In headquarter-intensive sectors, if the "Standard Effect" dominates, the share of intrafirm trade decreases under import-and-assembly.

(2) If the "Surprise Effect" dominates, the share of intrafirm trade increases under import-and-assembly.

(3) The relationship is ambiguous for pure-assembly, and is absent in assembly-intensive sectors.

To examine this hypothesis, we estimate the following equation:

$$\frac{X_j^{kV}}{X_j^{kV}+X_j^{kO}} = \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \delta_Z Z_j + \delta_{Z\eta} Z_j \eta_j + \epsilon_j, \tag{12}$$

where Z_j stands for the contractibility of the assembly plant's inputs. A higher Z_j represents a higher degree of contractibility. We adopt this measure from Nunn (2007), which equals one minus the share of intermediate inputs for production in a sector that are not sold on exchange or reference-priced. η_j is a measure of one of the factor intensities. Hypothesis 3 predicts that δ_Z and δ_η can be positive or negative for both the pure-assembly or import-and-assembly regimes.

Table 13 reports estimates of (12) for a sample of unilateral exports to each country in a sector. Headquarter intensity measures are always controlled for. For import-and-assembly exports, when capital and equipment intensities are used to represent headquarter intensity, we find negative and statistically significant coefficients on the interaction term between input contractibility and headquarter intensity. Thus, an increased contractibility of the supplier's inputs is found to reduce the share of intrafirm trade in the more headquarter-intensive sectors. This result suggests the dominance of the "Standard Effect." We find no relationship between contract completeness and the prevalence of intrafirm trade for the pure-assembly regime. This is expected for the same reason that headquarter intensity has an indeterminate impact on the prevalence of intrafirm trade. Using the sample of exports to the U.S. only, we find results consistent with Table 13 (see Table A3 in the appendix).

To identify the cut-off level of headquarter intensity over which contract completeness of inputs affects intrafirm trade, we follow Nunn and Trefler (2007) and consider a regression that allows the relationship between the contractibility of suppliers' inputs and intrafirm exports to differ by quintiles of headquarter intensity. Similar to our exploration of the non-linear relationship for productivity dispersion above, we first rank our SIC-1987 industries by headquarter intensity. Then we divide the industries into 5 quintiles of headquarter intensity. We estimate equation (13) below which includes interaction terms between the quintile dummies and the contractibility measure. The equation also includes country fixed effects, headquarter intensity quintile dummies and headquarter intensity controls. The standard errors are clustered at the industry level.

$$\frac{X_j^{kV}}{X_j^{kV}+X_j^{kO}} = d_c + \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \sum_{p=1}^{5} \delta_{\eta p} I_{jp}^{\eta} + \sum_{p=1}^{5} \delta_{Z\eta p}(Z_j * I_{jp}^{\eta}) + \epsilon_j, \tag{13}$$

The results are reported in Table 14 For import-and-assembly (columns (1) to (3)), we find that the negative impact on intrafirm trade arising from the interaction between input contractibility and headquarter intensity is due to the effects in the (highest) 5th quantile of headquarter-intensive sectors. In particular, the coefficient on the interaction between the 5th quantile dummy and the contractibility measure becomes negative and statistically significant when capital and equipment-capital intensities are used as proxies for headquarter intensity. For pure-assembly (columns (4) to (6)), we find no strong relationship.

After examining the cross-sector variation in the contractibility of inputs, we also explore the large cross-province variation in the quality of legal institutions in China to examine the impact of this variation on the prevalence of intrafirm trade across provinces. Interestingly, our results depend on how we measure headquarter intensity. Table 15 reports the results. For import-and-assembly exports (columns (1) to (3)), If skill intensity is used as a proxy for headquarter intensity, we find that an improvement in legal institution in the province is associated with a negative impact in sectors with higher headquarter intensity. This result supports the dominance of the "Standard Effect," and are consistent with the results in Table 14. That is, improving legal institutions alleviates the hold-up problem, and thus reduces the share of intrafirm trade observed. If we use capital or equipment intensities as proxies for headquarter intensity, the opposite results are obtained – more intrafirm trade is observed when legal institutions improve, particularly in the more headquarter-intensive sectors. These positive signs support the dominance of the "Surprise Effect," contrasting the conventional wisdom. Turning to the pure-assembly regime (columns (4) to (6)), there is evidence that in provinces with better legal institutions, the share of intrafirm trade is on average lower for all sectors. This across-the-board "Standard Effect" does not appear to be stronger in headquarter-intensive sectors. More research is needed to understand the changes in the dominance of the two effects when different headquarter intensity measures are used.

6 Conclusions

This paper explores the determinants of intrafirm trade in export processing in China. We present an extension of Antràs and Helpman (2004) to consider component search for assembling. Our model shows that control rights and ownership over components, together with asset ownership, should be given to the party whose investments are more important in production. By considering two ownership structures under two trade regimes, which differ in the allocation of control rights over components, our model predicts that headquarter intensity and the prevalence of intrafirm trade are positively correlated under the import-and-assembly regime. The relationship is ambiguous under pure-assembly.

We test the model using disaggregated Chinese export data and find three main sets of results that support the theoretical predictions. First, we find that under import-and-assembly, the prevalence of intrafirm exports is increasing in the intensity of headquarter inputs (skill and capital-equipment) across sectors. Second, the prevalence of intrafirm exports is decreasing in the contractibility of the supplier's inputs. However, this negative relationship turns positive when we use cross-province variation in institutional quality to identify the impact of input contractibility. For pure-assembly exports, however, we find little evidence that headquarter intensities nor input contractibility affects the prevalence of intrafirm trade.

Third, consistent with the sorting of firms into different production modes based on productivity, we find that larger productivity dispersion is associated with a bigger share of intrafirm exports under the pure-assembly regime, but not under the import-and-assembly regime. In particular, in sectors with higher headquarter intensity, the share of intrafirm trade increases with firm productivity dispersion. These three sets of results complement existing findings based on the headquarter's side of the story in developed countries, and validate the predictions of the theoretical literature on contracting, organizational structure, and international trade.

7 References

1. Antràs, P. (2003), "Firms, Contracts and Trade Structure", *Quarterly Journal of Economics*, 118(4), 1375-1418.

2. Antràs, P. (2005), "Incomplete Contracts and the Product Cycle," *American Economic Review*, 95(4), 1054–1073.

3. Antràs, P. and E. Helpman (2004), "Global Sourcing", *Journal of Political Economy,* 112(3), 552-580.

4. Antràs, P. and E. Helpman (2008), "Contractual Frictions and Global Sourcing", in E. Helpman, D. , D. Martin and T Verdier eds., *The Organization of Firms in a Global Economy*, Harvard University Press.

5. Bartelsman, Eric J. and Wayne Gray, "The NBER Manufacturing Productivity Database," Technical Working Paper No. 205, National Bureau of Economic Research, October 1996.

6. Bernard, A., J. Jensen and S. Redding (2008), "Intrafirm Trade and Product Contractibility", Yale School of Management Working Paper.

7. Bernard, A., J. Jensen, S. Redding and P. Schott (2007), "Firms in International Trade", *Journal of Economic Perspectives*, Vol. 21, No. 3, pp. 105–130.

8. Corcos, G., Delphine I., Mion G. and Verdier T. (2008), "The Determinants of Intra-Firm Trade," Centro Studi Luca D'Agliano Working Paper No. 267.

9. Defever, Fabrice and Farid Toubal (2007), "Productivity and the Sourcing Modes of Multinational Firms: Evidence from French Firm-Level Data," CEP Discussion Paper No. 842.

10. Fan J., J. Huang, R. Morck and B. Yeung (2008), "Vertical Integration, Institutional Determinants and Impact: Evidence from China, " Chinese Unversity Working Paper.

11. Feenstra R. and Hanson G. (2005) "Ownership and Control in Outsourcing to China: Estimating the Property-Rights Theory of the Firm," *Quarterly Journal of Economics* 120, No. 2, pp. 729-761.

12. Grossman, G. and E. Helpman (2002), "Integration versus Outsourcing in Industry Equilibrium", *Quarterly Journal of Economics* 117, pp. 85-120

13. Grossman, G. and E. Helpman (2003), "Outsourcing versus FDI in Industry Equilibrium," *Journal of the European Economic Association* 1, 317–327.

14. Grossman, G. and E. Helpman (2004), "Managerial Incentives and the International Organization of Production," *Journal of International Economics*, 63, 237–262.

15. Grossman, G. and E. Helpman (2005), "Outsourcing in a Global Economy," *Review of Economic Studies*, 72, 135–159.

16. Grossman, S. and Hart O. (1986), "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy,* 94 No.4 pp. 691-

17. Helpman, E., M. Melitz, and S. Yeaple (2004) "Export versus FDI with Heterogeneous Firms," *American Economic Review*, 94, No. 1, 300–316.

18. Levchenko, A. (2007), "Institutional Quality and International Trade," *Review of Economic Studies*, 74:3, pp. 791-819.

19. Manova, Kalina [2007], "Credit Constraints, Heterogeneous Firms and International Trade," Stanford University Manuscript.

20. McLaren, J., (2000) "Globalization and Vertical Structure," *American Economic Review*, 90, 1239-1254.

21. Nunn, Nathan (2007) "Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade," *Quarterly Journal of Economics*, 122 No. 2, pp.569-600.

22. Nunn, N. and D. Trefler (2008), "The Boundaries of the Multinational Firm: An Empirical Analysis", in E. Helpman, D. Martin and T Verdier eds., *The Organization of Firms in a Global Economy*, Harvard University Press.

23. Rajan, R. and L. Zingales (1998), "Financial Dependence and Growth," *American Economic Review,* 88:3, pp. 559-586.

24. Romalis, J. (2003), "Factor Proportions and the Structure of Commodity Trade," *American Economic Review* , 94:1, pp. 67-97.

25. Yeaple, S. (2006), "Offshoring, Foreign Direct Investment, and the Structure of U.S. Trade", *Journal of the European Economic Association* 4(2–3), 602–611.

A Appendix

In the pure-assembly regime, for a given organizational form l, solving the first order conditions of the headquarter's problem and the assembly plant's problem simultaneously give the following profit-maximization investment levels:With three equations and three unknowns, we can solve for the profit-maximization investments as

$$\begin{aligned}
\lambda m &= \eta^m \left[\left(\frac{\beta_{Nl}}{1-\beta_{Nl}} \right)^{\alpha \eta^a} \frac{\left(w^{S\eta^a} w^{N\eta^h} \lambda^{\eta^m} \right)^{\alpha}}{\alpha \beta_{Nl} D^{1-\alpha} \theta^{\alpha}} \right]^{\frac{1}{\alpha-1}} \\
w^S a &= \frac{\eta_j^a \left(1-\beta_{Nl}\right)}{\beta_{Nl}} \left[\left(\frac{\beta_{Nl}}{1-\beta_{Nl}} \right)^{\alpha \eta^a} \frac{\left(w^{S\eta^a} w^{N\eta^h} \lambda^{\eta^m} \right)^{\alpha}}{\alpha \beta_{Nl} D^{1-\alpha} \theta^{\alpha}} \right]^{\frac{1}{\alpha-1}} \\
w^N h &= \eta^h \left[\left(\frac{\beta_{Nl}}{1-\beta_{Nl}} \right)^{\alpha \eta^a} \frac{\left(w^{S\eta^a} w^{N\eta^h} \lambda^{\eta^m} \right)^{\alpha}}{\alpha \beta_{Nl} D^{1-\alpha} \theta^{\alpha}} \right]^{\frac{1}{\alpha-1}}
\end{aligned}$$

Plug these investment functions into the joint profit function of the firm, we obtain firm operating profit in terms of η^a as $\pi_{Nl} = \psi_{Nl} D\Theta$, where $\Theta \equiv \theta^{\frac{\alpha}{1-\alpha}}$

$$\psi_{Nl}\left(\beta_{Nl}, \eta^a, \eta^h\right) = \frac{1-\alpha\left[\beta_{Nl}\eta^h + \beta_{Nl}\eta^m + \left(1-\beta_{Nl}\right)\eta^a\right]}{\left[\frac{1}{\alpha}\left(\frac{\lambda}{\beta_{Nl}}\right)^{\eta^m}\left(\frac{w^S}{1-\beta_{Nl}}\right)^{\eta^a}\left(\frac{w^N}{\beta_{Nl}}\right)^{\eta^h}\right]^{\frac{\alpha}{1-\alpha}}}.$$

The function ψ_{Nl} reaches its maximum when $\frac{d\psi_{Nl}}{d\beta_{Nl}} = 0$. Solving this equation yields

$$\beta_N^*\left(\eta^h\right) = \frac{-\omega\left(\eta^h\right)\left(1-\alpha\omega\left(\eta^h\right)\right) + \sqrt{\eta^a\left(1-\omega\left(\eta^h\right)\right)\left(1-\alpha\omega\left(\eta^h\right)\right)\left(1-\alpha\left(1-\omega\left(\eta^h\right)\right)\right)}}{2\omega\left(\eta^h\right)-1},$$

where $\omega\left(\eta^h\right) = 1 - \eta^m - \eta^h$.

In the import-and-assembly regime, for a given organizational form l, solving the first order conditions of the headquarter's problem and the assembly plant's problem simultaneously give the following profit-maximization investment levels:

$$\lambda m = \eta^m \left[\left(\frac{\beta_{Sl}}{1-\beta_{Sl}} \right)^{1-\alpha\eta^h} \frac{\left(w^{S\eta^a} w^{N\eta^h} \lambda^{\eta^m} \right)^\alpha}{\alpha\beta_{Sl} D^{1-\alpha} \theta^\alpha} \right]^{\frac{1}{\alpha-1}}$$

$$w^S a = \eta^a \left[\left(\frac{\beta_{Sl}}{1-\beta_{Sl}} \right)^{1-\alpha\eta^h} \frac{\left(w^{S\eta^a} w^{N\eta^h} \lambda^{\eta^m} \right)^\alpha}{\alpha\beta_{Sl} D^{1-\alpha} \theta^\alpha} \right]^{\frac{1}{\alpha-1}}$$

$$w^N h = \eta^h \left(\frac{\beta_{Sl}}{1-\beta_{Sl}} \right) \left[\left(\frac{\beta_{Sl}}{1-\beta_{Sl}} \right)^{1-\alpha\eta^h} \frac{\left(w^{S\eta^a} w^{N\eta^h} \lambda^{\eta^m} \right)^\alpha}{\alpha\beta_{Sl} D^{1-\alpha} \theta^\alpha} \right]^{\frac{1}{\alpha-1}}$$

Plug these investment functions into the joint profit function of the firm, we obtain firm operating profit in terms of η^m and η^h as $\pi = \psi_{Sl}\left(\beta_{Sl}, \eta^m, \eta^h\right) D\Theta$, where $\Theta \equiv \theta^{\frac{\alpha}{1-\alpha}}$

$$\psi_{Sl}\left(\beta_{Sl}, \eta^a, \eta^h\right) = \frac{1-\alpha\left[\beta_{Sl}\eta^h + (1-\beta_{Sl})\left(1-\eta^h\right)\right]}{\left[\frac{1}{\alpha}\left(\frac{\lambda}{1-\beta_{Sl}}\right)^{\eta^m}\left(\frac{w^S}{1-\beta_{Sl}}\right)^{\eta^a}\left(\frac{w^N}{\beta_{Sl}}\right)^{\eta^h}\right]^{\frac{\alpha}{1-\alpha}}}.$$

The function ψ_{Sl} reaches its maximum when $\frac{d\psi_{Sl}}{d\beta_{Sl}} = 0$, which implies

$$\beta_S^*\left(\eta^h\right) = \frac{-\eta^h\left(1-\alpha\left(1-\eta^h\right)\right) + \sqrt{\eta^h\left(1-\eta^h\right)\left(1-\alpha\eta^h\right)\left(1-\alpha\left(1-\eta^h\right)\right)}}{2\left(1-\eta^h\right)-1}$$

To derive the inequality in (4), we rearrange $\psi_{Nl}\left(\beta_{Nl}, \eta^a, \eta^h\right) > \psi_{Sl}\left(\beta_{Sl}, \eta^a, \eta^h\right)$ for a given organizational mode l.

For the discussion of the share of different production modes when η^h increases, notice that

$$\begin{aligned} & \frac{\psi_{NO}\left(\beta_{NO}, \eta^a, \eta^h\right)}{\psi_{SV}\left(\beta_{SV}, \eta^a, \eta^h\right)} \\ = & \frac{1-\alpha\left[\beta_{SV}\eta^h + (1-\beta_{SV})\left(1-\eta^h\right)\right]}{1-\alpha\left[\beta_{NO}\eta^h + (1-\beta_{NO})\left(1-\eta^h\right) + (2\beta_{NO}-1)\,\eta^m\right]} \\ & \div \left[\left(\frac{\lambda_N}{\lambda_S}\frac{\beta_{Nl}}{1-\beta_{Sl}}\right)^{\eta^m}\left(\frac{1-\beta_{Nl}}{1-\beta_{Sl}}\right)^{(1-\eta^m)-\eta^h}\left(\frac{\beta_{Nl}}{\beta_{Sl}}\right)^{\eta^h}\right]^{\frac{\alpha}{1-\alpha}}. \end{aligned}$$

It is clear that keeping η^m constant, ψ_{NO}/ψ_{SV} is increasing with η^h.

Table 2 – Export shares of each trade regimes (2005)

	Total processing	Pure-assembly	Import-and-assembly
US $1 billion	416.48	83.97	332.51
Share of total exports	54.70%	11.00%	43.60%
Share of exports by FOE	80.60%	50.00%	88.30%

Source: Chinese export data from the Customs General Administration of the People's Republic of China

Table 3 – Export shares of 4 ownership x trade-regime modes (2005)

		Organizational Forms		
		Integration (V)	Outsourcing (O)	
Component Search	Pure-assembly (N)	9.67%	12.22%	21.89%
	Import-and-assembly (S)	59.71%	18.40%	78.11%
		69.38%	30.62%	

Source: Chinese export data from the Customs General Administration of the People's Republic of China

Table 4 - Headquarter Intensity and Intrafirm Exports (SIC4 level)

Trade Regimes:	Import-and-assembly			Pure-assembly		
	(1)	(2)	(3)	(4)	(5)	(6)
Skill Intensity, ln(H/L)	0.131***	0.117***	0.116**	-0.041	-0.041	-0.041
	(2.934)	(2.594)	(2.571)	(-0.771)	(-0.746)	(-0.743)
Capital Intensity, ln(K/L)	-0.189***	-0.138**		0.103*	0.102	
	(-3.077)	(-2.012)		(1.653)	(1.480)	
Material Intensity, ln(M/L)		-0.094	-0.077		0.001	-0.006
		(-1.382)	(-1.124)		(0.008)	(-0.082)
Equipment Intensity, ln(E/L)			0.133			-0.036
			(1.574)			(-0.403)
Plant Intensity, ln(P/L)			-0.307***			0.152
			(-3.648)			-1.642
N	349	349	349	331	331	331
R^2	.059	.065	.09	0.013	0.013	0.018

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 4-digit SIC industry.
Standardized beta coefficients are reported. t-stats based on robust standard errors are in parentheses.
*p<0.10, ** p<0.05, *** p<0.01.

Table 5 - Headquarter Intensity and Intrafirm Exports (HS6 level)

Trade Regimes:	Import-and-assembly			Pure-assembly		
	(1)	(2)	(3)	(4)	(5)	(6)
Skill Intensity, ln(H/L)	0.121***	0.115***	0.115***	-0.046	-0.042	-0.044
	(3.197)	(2.882)	(2.923)	(-1.206)	(-1.104)	(-1.131)
Capital Intensity, ln(K/L)	-0.123***	-0.091**		-0.024	-0.039	
	(-2.877)	(-2.120)		(-0.798)	(-1.040)	
Material Intensity, ln(M/L)		-0.055	-0.049		0.028	0.028
		(-1.215)	(-1.091)		(0.754)	(0.722)
Equipment Intensity, ln(E/L)			0.059			-0.101*
			(1.061)			(-1.847)
Plant Intensity, ln(P/L)			-0.167***			0.062
			(-3.363)			-1.049
N	3,478	3,478	3,478	2,750	2,750	2,750
No. clusters	349	349	349	331	331	331
R^2	.034	.036	.043	0.0022	0.0028	0.0056

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*p<0.10, ** p<0.05, *** p<0.01.

Table 6 - Headquarter Intensity and Intrafirm Exports to Each Country (HS6 level)

Trade Regimes:	Import-and-assembly			Pure-assembly		
	(1)	(2)	(3)	(4)	(5)	(6)
Skill Intensity, ln(H/L)	0.175***	0.169***	0.167***	-0.087**	-0.088**	-0.089***
	(5.349)	(4.655)	(4.874)	(-2.578)	(-2.573)	(-2.602)
Capital Intensity, ln(K/L)	-0.086**	-0.039		0.030	0.037	
	(-2.131)	(-1.110)		(0.764)	(0.805)	
Material Intensity, ln(M/L)		-0.086**	-0.084**		-0.015	-0.021
		(-2.306)	(-2.267)		(-0.384)	(-0.570)
Equipment Intensity, ln(E/L)			0.096**			-0.103**
			(2.492)			(-2.212)
Plant Intensity, ln(P/L)			-0.149***			0.155***
			(-3.828)			(4.016)
Country Fixed Effects	yes	yes	yes	yes	yes	yes
N	72,030	72,030	72,030	34,551	34,551	34,551
No. clusters	349	349	349	331	331	331
R^2	.064	.069	.078	.081	.081	.093

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*p<0.10, ** p<0.05, *** p<0.01.

Table 7 - Headquarter Intensity and Intrafirm Exports under Import-and-assembly (Different Country Groups) (HS6 level)

	(1)	(2)	(3)	(4)	(6)	(5)
Country Group:	LIC	HIC	US	JAPAN	Europe (HIC)	Exclude HK
Skill intensity, ln(H/L)	0.170***	0.108***	0.131***	0.129***	0.138***	0.132***
	(4.149)	(2.753)	(3.548)	(3.498)	(3.112)	(3.036)
Material Intensity, ln(M/L)	-0.067	-0.058	-0.087*	-0.071*	-0.067	-0.047
	(-1.388)	(-1.264)	(-1.903)	(-1.727)	(-1.367)	(-0.961)
Equipment Intensity, ln(E/L)	0.155**	0.038	0.104**	0.131***	0.072	0.103*
	(2.044)	(0.709)	-2.02	(2.841)	(1.193)	(1.774)
Plant Intensity, ln(P/L)	-0.195***	-0.139***	-0.188***	-0.191***	-0.184***	-0.219***
	(-2.860)	(-3.049)	(-3.970)	(-4.669)	(-2.963)	(-3.435)
N	1363	3394	2,302	2482	2402	3347
No. clusters	271	346	316	327	319	347
No. countries	47	59	1	1	38	233
R^2	.055	.039	0.054	.045	.056	.054

Dependent Variable: China's intrafirm exports as a share of total exports under the import-and-assembly regime.
Country classification by the World Bank according to GNI per capita in 2007. LIC stands for Low income countries. HIC stands for High income countries
An observation is a 6-digit HS product category to each country group.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*p<0.10, ** p<0.05, *** p<0.01.

Table 8 - Headquarter Intensity and Intrafirm Exports under Pure-assembly (Different Country Groups) (HS6 level)

	(1)	(2)	(3)	(4)	(6)	(5)
Country Group:	LIC	HIC	US	JAPAN	Europe (HIC)	Exclude HK
Skill intensity, ln(H/L)	-0.112*	-0.043	-0.054	-0.123***	-0.090**	-0.084**
	(-1.772)	(-1.075)	(-1.280)	(-3.436)	(-2.158)	(-2.262)
Material Intensity, ln(M/L)	-0.036	0.028	0.031	0.043	0.016	0.018
	(-0.496)	(0.707)	(0.675)	(1.122)	(0.311)	(0.455)
Equipment Intensity, ln(E/L)	0.172*	-0.117**	-0.170***	-0.143**	-0.070	-0.065
	(1.918)	(-2.127)	(-3.476)	(-2.341)	(-1.277)	(-1.226)
Plant Intensity, ln(P/L)	0.012	0.068	0.159***	0.094	0.141**	0.067
	(0.135)	(1.155)	(3.023)	(1.597)	(2.270)	(1.184)
N	547	2689	1,585	1743	1524	2479
No. clusters	182	330	286	289	280	321
No. countries	47	59	1	1	38	233
R^2	.048	.007	.02	0.025	.021	.010

Dependent Variable: China's intrafirm exports as a share of total exports under the pure-assembly regime.
Country classification by the World Bank according to GNI per capita in 2007. LIC stands for Low income countries. HIC stands for High income countries
An observation is a 6-digit HS product category to each country group.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*p<0.10, ** p<0.05, *** p<0.01.

Table 9 - Headquarter Intensity and Intrafirm Exports (Using Chinese data to measure factor intensities) (HS6 Level)

Trade Regime	Import-and-assembly		Pure-assembly	
	(1)	(2)	(3)	(4)
Observation Unit	HS6 Level	HS6 country level	HS6 Level	HS6 country level
Skill intensity	0.099***	0.109***	-0.095***	-0.107***
	(2.711)	(3.537)	(-2.691)	(-2.636)
Capital Intensity	-0.188***	-0.138***	0.026	0.001
	(-5.292)	(-3.568)	(0.638)	(0.010)
Country fixed effects	no	yes	no	yes
N	3505	72177	2770	34624
No. clusters	360	360	344	344
R^2	.03	.046	.0079	.084

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime
Country classification by the World Bank according to GNI per capita in 2007. LIC stands for Low income countries. HIC stands for High income countries
An observation is a 6-digit HS product category to each country group.
Skill intensity is measured by the average share of high-school workers in the labor force of each sector, averaged across firms.
Capital intensity is measured by the average ratio of real value of capital to real output across firms.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*p<0.10, ** p<0.05, *** p<0.01.

Table 10 - Productivity Dispersion and Intrafirm Trade, (Exports to Each Country; US-export-based dispersion measures) (HS6-country level)

Dependent Variable: China's intrafirm exports as a share of total exports						
	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Dispersion	0.009	0.117***	0.057**	0.297***	-0.060	0.044*
	(0.173)	(3.401)	(2.590)	(3.577)	(-1.510)	(1.966)
Dispersion Interaction	-0.012	-0.363***	-0.343***	0.468***	0.561***	0.603***
	(-0.091)	(-2.925)	(-3.112)	(2.838)	(3.287)	(4.070)
Country fixed effects	yes	yes	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	71,966	71,966	71,966	34,541	34,541	34,541
No. clusters	347	347	347	329	329	329
R^2	0.077	0.073	0.081	.100	.092	.110

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table 11 - Productivity Dispersion and Intrafirm Trade (Exports to Each Country, using Chinese-export-based dispersion measures) (HS6-country level)

Dependent Variable: China's intrafirm exports as a share of total exports						
	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Dispersion	0.132**	0.060	0.063*	0.206**	-0.211***	-0.055
	(2.354)	(1.325)	(1.832)	(2.320)	(-2.815)	(-1.259)
Dispersion Interaction	0.115	0.297	0.309	0.537*	1.102***	0.970***
	(0.578)	(1.353)	(1.449)	(1.883)	(2.764)	(2.810)
Country fixed effects	yes	yes	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	72030	72030	72030	34551	34551	34551
No. clusters	349	349	349	331	331	331
R^2	.086	.083	.087	.100	.095	.110

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table 12 - Productivity Dispersion and Intrafirm Trade (Exports to each country; Interaction with Different Headquarter-intensity Quintiles) (HS6-country Level)

	Import and assembly					Pure assembly				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Headquarter intensity measure:	--	--	skill	capital	equipment	--	--	skill	capital	equipment
Dispersion	0.014	0.007				0.090***	0.080***			
	(0.762)	(0.395)				(3.307)	(3.273)			
Dispersion interacted with:										
Ii1			0.092	0.198**	0.204***			0.173	0.058	0.020
			(0.796)	(2.518)	(3.108)			(1.476)	(0.590)	(0.261)
Ii2			-0.043	0.089	-0.003			-0.148**	-0.256**	0.026
			(-0.324)	(0.671)	(-0.033)			(-2.257)	(-2.054)	(0.280)
Ii3			0.133	0.165*	0.051			-0.008	0.033	0.178
			(1.251)	(1.753)	(0.409)			(-0.061)	(0.256)	(0.858)
Ii4			-0.041	0.092	0.069			0.152	0.349***	0.506***
			(-0.331)	(1.108)	(0.746)			(1.395)	(2.664)	(2.950)
Ii5			-0.039	-0.080	-0.108			0.714***	0.477***	0.489***
			(-0.458)	(-0.679)	(-1.027)			(4.064)	(4.020)	(4.449)
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Quintile fixed effects	no	yes	yes	yes	yes	no	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	71966	71966	71966	71966	71966	34541	34541	34541	34541	34541
No. clusters	347	347	347	347	347	329	329	329	329	329
R^2	.077	.092	.082	.082	.085	.03	.12	.11	.10	.12

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table 13 - Contractual Completeness and Intrafirm Trade (Exports to Each Country) (HS6-country level)

	Import-and-assembly			Pure-assembly		
	(1)	(2)	(3)	(4)	(5)	(6)
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Contractibility	-0.053	0.124**	0.054	-0.038	-0.04	0.006
	(-0.471)	(2.092)	(1.344)	(-0.315)	(-0.604)	(0.126)
Contractibility Interaction	0.016	-0.354***	-0.328***	-0.141	0.185	0.166
	(0.117)	(-3.358)	(-3.572)	(-0.809)	(1.466)	(1.452)
Country fixed effects	yes	yes	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	58,587	58,587	58,587	26,158	26,158	26,158
No. clusters	282	282	282	265	265	265
R^2	.083	.088	.094	0.089	0.091	0.092

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table 14 - Contractual Completeness and Intrafirm Trade (Exports to Each Country, Interaction with Different Headquarter-intensity Quintiles) (HS6-country level)

	Import-and-assembly			Pure-assembly		
	(1)	(2)	(3)	(4)	(5)	(6)
Headquarter intensity measure	Skill	Capital	Equipment	Skill	Capital	Equipment
Contractibility interacted with						
Ii1	-0.089	0.124***	0.107**	0.161*	0.033	-0.002
	(-1.382)	(2.619)	(2.157)	(1.879)	(0.505)	(-0.032)
Ii2	-0.129*	0.057	0.091	-0.025	-0.021	-0.009
	(-1.672)	(0.724)	(1.598)	(-0.381)	(-0.304)	(-0.170)
Ii3	0.086*	-0.091	-0.079	0.006	0.140**	0.181***
	(1.704)	(-1.063)	(-1.029)	(0.061)	(2.375)	(2.780)
Ii4	-0.066	-0.003	-0.030	0.116	-0.023	0.007
	(-0.645)	(-0.095)	(-0.864)	(1.508)	(-0.532)	(0.159)
Ii5	-0.036	-0.174**	-0.225***	0.097	0.053	0.057
	(-0.654)	(-2.451)	(-3.095)	(1.164)	(0.514)	(0.539)
Country fixed effects	yes	yes	yes	yes	yes	yes
Quintile fixed effects	yes	yes	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	58587	58587	58587	26158	26158	26158
No. Clusters	282	282	282	265	265	265
R^2	.091	.094	.099	0.1	0.11	0.1

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.

Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table 15 – Legal Institutional Quality and Intrafirm Trade (HS6-province level)

	Import-and-assembly			Pure-assembly		
	(1)	(2)	(3)	(4)	(5)	(6)
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Legal development	0.050	0.125***	0.161***	-0.271***	-0.263***	-0.265***
	(1.201)	(7.326)	(13.675)	(-4.859)	(-11.646)	(-17.447)
Legal_develop. interaction	-0.320***	0.290***	0.265***	-0.004	-0.045	-0.083
	(-3.287)	(3.939)	(3.836)	(-0.029)	(-0.427)	(-0.793)
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	15443	15443	15443	9207	9207	9207
No. clusters	349	349	349	331	331	331
R^2	.078	.058	.078	.081	.08	.081

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category from each province to the rest of the world.
Legal development measures the effectiveness of the courts (Fan et al., 2001). See data section for a description.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.
.

Appendix Tables

Table A1 - Productivity Dispersion and Intrafirm Trade, Exports to the U.S. (HS6 level)

	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Dispersion	-0.008	0.157***	0.069**	0.519***	-0.026	0.078**
	(-0.126)	(3.833)	(2.362)	(4.793	(-0.553)	(2.441)
Dispersion Interaction	-0.037	-0.501***	-0.471***	0.853***	0.452**	0.521***
	(-0.268)	(-3.669)	(-3.766)	(4.081	(2.550)	(3.434)
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	2,302	2,302	2,302	1,584	1,584	1,584
No. clusters	316	316	316	285	285	285
R^2	.054	.050	.061	0.047	0.014	0.04

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to the U.S.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table A2 - Productivity Dispersion and Intrafirm Trade (Exports to Each Country, Chinese-sales-based dispersion measures) (HS6-country level)

Dependent Variable: China's intrafirm exports as a share of total exports						
	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Dispersion	0.148***	0.031	-0.009	0.254***	-0.129	0.006
	(3.225)	(0.370)	(-0.134)	(3.669)	(-1.49s4)	(0.099)
Dispersion Interaction	0.340**	-0.086	0.031	0.369***	0.576**	0.445
	(2.548)	(-0.456)	(0.150)	(3.036)	(2.204)	(1.587)
Country fixed effects	yes	yes	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	63368	63368	63368	31041	31041	31041
No. clusters	314	314	314	300	300	300
R^2	.075	.064	.071	.100	.087	.100

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to each country.
The measure of productivity dispersion is the standard deviation of log sales across Chinese firms within each sector. Sales data of Chinese firms are from Annual Survey of Industrial Production (1998-2005), conducted by the Chinese National Bureau of Statistics.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.

Table A3 - Contractual Completeness and Intrafirm Trade (Exports to the U.S.) (HS6 level)

Trade Regime	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
Contractibility	-0.028	0.111*	0.049	-0.170	-0.006	0.026
	(-0.227)	(1.709)	(1.057)	(-1.209)	(-0.092)	(0.519)
Contractibility interaction	0.047	-0.349***	-0.334***	-0.326*	0.117	0.092
	(0.290)	(-2.673)	(-2.934)	(-1.736)	(0.903)	(0.778)
Headquarter intensity controls	yes	yes	yes	yes	yes	yes
N	1,842	1,842	1,842	1,219	1,219	1,219
No. clusters	254	254	254	225	225	225
r2	.053	.061	.063	0.01	0.0054	0.0055

Dependent Variable: China's intrafirm exports as a share of total exports under each trade regime.
An observation is a 6-digit HS product category to the U.S.
Standardized beta coefficients are reported. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
In columns (1), (2), (4) and (5), Headquarter intensity controls include ln(H/L), ln(K/L), ln(M/L).
In columns (3) and (6), Headquarter intensity controls include ln(H/L), ln(M/L), ln(E/L) and ln(P/L).
*p<0.10, ** p<0.05, *** p<0.01.