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

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Abstract

This paper uses detailed product-level export data for China and an extension of the model by Antràs and Helpman (2004) that includes component search in processing trade to investigate the determinants of integration versus outsourcing. We exploit the coexistence of two regulatory trade regimes for export-processing in China, pure-assembly and import-and-assembly. We find that if Chinese plants import materials and assemble them, 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 are consistent with existing theories. However, if Chinese plants engage in pure-assembly, under which regime ownership over the materials shipped to China remains with the foreign firm, we find little support for existing theories on intrafirm trade that focus on the contract incompleteness and the relative importance of relationship-specific investments. We also find that 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's predictions.

Key Words Intrafirm trade, Vertical integration, Export processing, Outourcing
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1 Introduction

This paper uses detailed product-level trade data from China's customs to study the determinants of intrafirm trade in assembly. We exploit the coexistence of two regulatory regimes for export processing in China to help better understand what determines the prevalence of vertically integration versus outsourcing. 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.[1] However, empirical evidence is scant, and exclusively focused on the developed world. In contrast, we analyze the determinants of intrafirm trade from the perspective of the input suppliers and assembly plants in a rapidly developing country. In focusing on the subsidiary's side of a trade relationship, we hope to gain an insight into insourcing versus outsourcing in world trade. By focusing on a developing country, we complement existing findings based on the headquarter's side of the story in developed countries. Moreover, by taking advantage of the differences in ownership of the firm and control rights over the imported materials for assembly across the two regulatory regimes for export processing specific to China, we add to the empirical literature on validating the predictions of the theoretical models on contracting, organizational structure, and international trade. To guide our econometric analysis we extend the model by Antràs and Helpman (2004) to include component search in processing trade.

Export processing has played an important role in China's economic development and accounted for more than half of its exports in recent years. To promote export-led growth, the Chinese government offers substantial tariff reductions for export-processing plants. In particular, export processing in China has been governed under two regulatory regimes since the early 1980s, which are called 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 analysis on the determinants of intrafirm trade and deepen our understandings of export processing, we extend the 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

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

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.

Where firm productivity is heterogeneous, our model predicts that for the import-and-assembly regime, the fraction of integrated firms is increasing in headquarter intensity across sectors. This prediction is in the spirit of Antràs (2003). For the pure-assembly regime, we find an ambiguous relationship between sectoral headquarter intensity and the prevalence of integration. The reason is that when headquarter intensity increases, some firms switch from the import-and-assembly regime to the outsourcing mode under pure-assembly, while some firms switch from outsourcing to integration within pure-assembly. The net impact on the composition of organization modes within the pure-assembly regime is ambiguous.

We examine these theoretical predictions using detailed product-level trade data collected by China's customs. In particular, we regress the share of intrafirm trade at the HS 6-digit level for each trade regime on various measures of the intensity of headquarters inputs. 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 is consistent with the main prediction of Antràs (2003). The results are robust when we restrict exports only to the U.S. and to 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 to which investments are contractible is an important determinant of 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 the import-and-assembly regime.

Finally, we also explore the large cross-province variation in the quality of legal institutions in China to examine the role of institutional quality on the prevalence of intrafirm trade across provinces and sectors. 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. These studies find empirical support for the theoretical predictions of existing models. In this literature imports within multinationals' boundaries are 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). In our paper we 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, for import-and-assembly, validate the existing theoretical models that have so far put sourcing decisions by the headquarters in the North at the center of analysis. For pure-assembly the results are not consistent with existing theories.

Defever and Toubal (2007) and Corcos et al. (2008) provide firm-level evidence for France. 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.

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. We 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 the volume 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 export volume was classified under import-and-assembly in 2005, with the rest classified as pure-assembly exports. Of these import-and-assembly exports, 76 percent was associated with foreign affiliated plants, which we take as intrafirm exports. Of the pure-assembly exports, the share of foreign-affiliate exports 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.[2]

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 certain standard for their accounting practices and warehouse facilities. Since imports are duty-free, firms have a great incentive to apply to operate their production units under either of the regimes. Therefore, China's customs is particularly restrictive about the use of imported materials by the Chinese export-processing plants. 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 both our model and empirical analyses. The first difference is related to the responsibilities of the Chinese plant,

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

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 standard according to the government's requirements. The 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 Model Setup

To guide our empirical analysis, we extend the North-South trade model with heterogeneous firms by Antràs and Helpman (2004) to include component search in processing trade. Consider an environment in which all consumers have the same constant elasticity-of-substitution preferences over a number of differentiated products. A firm that produces a brand of a differentiated product faces the demand function

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

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 of the brand.[3]

In our model, production requires non-cooperative investments by the final-good producer (H) in the North and the assembly plant (A) in the South. Specifically, final goods are produced with three inputs, component activities m, assembly activities a and headquarter services h, according

[3] 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, where μ is assumed to be smaller than α.

to the following production function:

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

where θ is firm productivity, $0 < \eta^m < 1$, $0 < \eta^a < 1$ and $\eta^h = 1 - \eta^m - \eta^a$.[4] 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 A in the South, while h is always chosen by H in the North. The unit cost of h is w^N, while that of a is $w^S < w^N$. Depending on the trade regime under which the production unit operates, either A or H 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 activities 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 $\lambda' s$.

For simplicity, we limit our analysis on H's decisions between foreign outsourcing and foreign vertical integration (i.e., FDI), and ignore all domestic sourcing modes. Irrespective of the trade regime, components m are always purchased and shipped from outside A's location. This is what the Chinese government requires export-processing plants to do. The foreign client H can choose to source assembly tasks either under the pure-assembly regime (N) or under the import-and-assembly regime (S). Within each regime, she can choose to outsource (O) to the assembly plant, or integrate (V) with it. In sum, there are four production modes that H can choose to operate her production unit. They are NV, NO, SV and SO.

The timing of events is as follows. First, a potential final-good producer (H) pays a fixed cost to enter the market and draw productivity θ for her future production unit. If the expected profits are negative, she exits the market; otherwise, she chooses one of the four production modes for production. Depending on the trade regime, different fixed costs need to be paid. After that, H is randomly matched with an assembly plant (A) in the South. Anticipating ex-post bargaining, both H and A then undertake non-contractible investments in inputs (a, h and m). Who invests in activities in component search (m) depends on which trade regime H chooses ex ante. After the inputs are produced, H and A bargain over the division of surplus in a Nash bargaining game. If they agree to continue the relationship, m are shipped from abroad to A, which are then assembled with a to produce finished products. Finally, the finished products are exported to H in the North for final processing.

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.

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

3.2 Equilibrium

We solve the model backwards for the subgame-perfect equilibrium for a given firm, taking sector-level variables as given. We derive a number of testable hypotheses related to the prevalence of intrafirm trade across sectors that are specific to export processing in China. Revenue of the joint production unit between the final-good producer and the assembly plant is given by

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

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

3.2.1 Pure-Assembly

Under pure-assembly, H has control rights and ownership of the components (m). 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. Following Antràs and Helpman (2004), we assume that after firing A, there is an efficiency loss because A has relationship-specific capital and is more productive than an outside manager. As such, H can complete only a fraction $\delta \in (0,1)$ of the original output, which implies a discounted outside option equal to $\delta^{\alpha}R < R$. Since A's investments are tailored specifically to H, her outside option is 0.[5]

Now consider outsourcing under pure-assembly. A's outside option is again equal to 0. Without asset ownership, H can no longer seize A's assets if bargaining fails. If H's investments are completely specific to A, H's outside option is also 0.

Let us denote H's expected payoff under integration by $\beta_{NV}R$, with the remaining share of the revenue going to A. Similarly, H's expected payoff under outsourcing is $\beta_{NO}R$. The above analysis of the outside options of each party implies

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

Solving the maximization problems of H and A gives operating profits of the joint production unit as $\pi_{Nk} = D\Theta\psi_{Nk} - w^N\phi_{Nk}$ (see appendix), where $k \in \{V, O\}$, $\Theta = \theta^{\frac{\alpha}{1-\alpha}}$ and ϕ_{Nk} is the fixed cost associated with organization mode k under pure-assembly. Importantly, the multiplicative

[5] If inputs are only partially specific to the relationship, A's outside option needs not be 0. This assumption is to simplify analysis, and the main insights of the paper is independent of the assumption of complete specificity.

part of the revenue that is sensitive to investment levels, and thus the production mode, is

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

3.2.2 Import-and-Assembly

We now turn to the analysis of the ex post distribution of joint surplus under import-and-assembly. We follow Feenstra and Hanson (2005) and assume that A's investments in component search activities give her a positive outside option. It can be because A acquires expertise and develops business networks from these investments, which allow her to serve as a potential partner for another final-good producer in the North. For simplicity, we assume that A's outside option is equal to a fraction of the original revenue, $\gamma R < R$.

If H chooses to integrate with the assembly plant, she can seize A's inputs and complete her production with a third-party plant if bargaining fails. H's outside option is once again $\delta^\alpha R < R$. We assume $\gamma + \delta^\alpha < 1$.

If H chooses outsourcing, she has no ownership of either A's assets or components. Her outside option is thus equal to 0, while A's outside option is once again γR. Let us denote H's expected payoff under integration and outsourcing by $\beta_{SV}R$ and $\beta_{SO}R$, respectively. The dependence of the outside options on the organization modes implies

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

It is important to note that for a given organization mode, A obtains a larger de-facto bargaining power under import-and-assembly because of her experience and business network acquired from searching for components.

Solving the maximization problems of H and A gives operating profits of the joint production unit as $\pi_{Sk} = D\Theta\psi_{Sk} - w^N\phi_{Sk}$ (see appendix), where k and Θ are as above, and ϕ_{Sk} is the fixed cost associated with organization mode k under import-and-assembly, and

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

3.2.3 Choosing Optimal Production Modes

If fixed costs are all identical, the model predictions are straightforward: all final-good producers choose outsourcing in assembly-intensive sectors, and integration in headquarter-intensive sectors.[6]

[6] If we derive the optimal β^*_{lk} that maximizes joint surplus (solving $\frac{d\psi_{lk}}{d\beta_{lk}} = 0$ for $l \in \{N, S\}$, $k \in \{V, O\}$) we obtain the folowing. Under import-and-assembly, $\beta_{SV} > \beta_{SO} > \beta^*_S\left(\eta^h\right)$ for an assembly-intensive sector, which implies

However, we observe different organizational forms across sectors from the data. Moreover, in practice, different organizational forms appear to be associated with different costs. We now consider fixed costs of production that vary across production modes.

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 a trade regime (N or S) and an organizational form (V or O) to operate its production unit. 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 $l \in \{N, S\}$. We assume that pure-assembly is associated with a higher fixed cost compared with import-and-assembly (i.e., $g_N > g_S$). The rationale is that it is more costly to set up a logistic network to transport components from overseas suppliers to the assembly plants.[7] 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 ranking of fixed costs as follows:[8]

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

Conditional on staying in the market, H chooses the production mode to maximize expected operating profits of the joint production unit before investments by each party as follows:

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

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 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,

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$\psi_{SO} > \psi_{SV}$. Similarly, under pure-assembly, $\beta_{NV} > \beta_{NO} > \beta_N^* \left(\eta^h\right)$ for an assembly-intensive sector, which implies $\psi_{NO} > \psi_{NV}$.

[7] Similar to the discussion about the fixed costs for different organizational forms, economies of scale can lower the transportation costs of components that come directly from the headquarter, instead from multiple suppliers. We assume that these economies of scale are not big enough to offset the cost saving from decentralization of component purchasing.

[8] 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 also 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.

it is natural to consider that the plant's manager is important for managing the local staff, and component ownership is an important determinant of the owner's outside option. Based on this argument, we focus on the following ranking of the $\beta's$ as our benchmark case:

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

The final-good producer's choices depend on ψ's and the fixed costs associated with different production modes. Let us focus on the discussion of the ranking of ψ's. As non-integration provides A with a higher incentive to invest, and is associated with a lower fixed cost, outsourcing is always the preferred organization mode within each trade regime in assembly-intensive sectors. After choosing the organizational form, H still has to compare profits across trade regimes. Since the fixed cost for outsourcing under pure-assembly is higher than that under import-and-assembly (i.e., $\phi_{NO} > \phi_{SO}$), H would consider pure-assembly only if $\psi_{NO} > \psi_{SO}$.

To verify this inequality, let us consider a constant component intensity η^m for simplicity. For a given organization mode k, $\psi_{Nk} > \psi_{Sk}$ if the following inequality holds:[9]

$$\left(\frac{\lambda^N}{\lambda^S}\right)^{\eta^m} \leq \frac{\varphi\left(\beta_{Nk}, \eta^h\right)}{\zeta\left(\beta_{Sk}, \eta^h\right)}, \tag{4}$$

where $\varphi\left(\xi, \eta^h\right) = \left[1 - \alpha\left(\xi\eta^h + \xi\eta^m + (1-\xi)\left(1-\eta^h-\eta^m\right)\right)\right]^{\frac{1-\alpha}{\alpha}} \xi^{\eta^h+\eta^m} (1-\xi)^{1-\eta^h-\eta^m}$ and $\zeta\left(\xi, \eta^h\right) = \left[1 - \alpha\left(\xi\eta^h + (1-\xi)\left(1-\eta^h\right)\right)\right]^{\frac{1-\alpha}{\alpha}} (1-\xi)^{1-\eta^h} \xi^{\eta^h}$. This inequality is more likely to hold if the final-good producer commands a bigger cost advantage over component search (i.e., λ^N/λ^S is smaller).[10] Otherwise, if $\lambda^S < \lambda^N$, H's bargaining power associated with outsourcing under pure-assembly needs to be significantly bigger than that under import-assembly (i.e., $\beta_{NO} >> \beta_{SO}$) for (4) to hold. For instance, if control rights over components greatly enhances A's outside option (i.e., high γ), β_{NO} can be much bigger than β_{SO}.

In assembly-intensive sectors where outsourcing is always the preferred organizational form, we have

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

In headquarter-intensive sectors, both integration and outsourcing can be optimal organization modes. Furthermore, since control and ownership over the components give the final-good producer

[9] We obtain this inequality by rearranging $\psi_{Nk}\left(\beta_{Nk}, \eta^a, \eta^h\right) > \psi_{Sk}\left(\beta_{Sk}, \eta^a, \eta^h\right)$ for a given organizational mode k.

[10] Notice that both φ 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 φ from above at $\xi > 1/2$, after which both ζ and φ are decreasing in ξ.

extra incentive to invest in headquarter services, pure-assembly is associated with a higher ψ than import-and-assembly. Importantly, inequality (4) always holds in headquarter-intensive sectors. All of these together imply $\psi_{NV} > \psi_{NO} > \psi_{SV} > \psi_{SO}$.[11]

We now examine how fixed costs affect firms' organizational choices in sectors of different headquarter intensities. In assembly-intensive sectors firms with productivity levels that are too low to make positive operating profits exit the market (i.e., when $D\Theta\psi_{SO} < w^N\phi_{SO}$). If $\psi_{NO} < \psi_{SO}$, outsourcing under import-and-assembly is the only equilibrium production mode since $\phi_{NO} > \phi_{SO}$. On the other hand, if $\psi_{NO} \geq \psi_{SO}$ (when (4) holds), firms with high-enough productivity levels outsource assembly tasks under the pure-assembly regime, as illustrated in Figures 1.

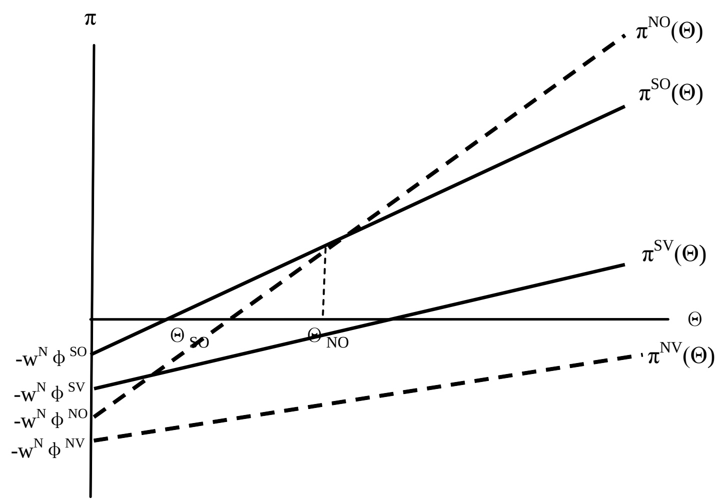

Figure 1: Assembly-intensive sector when $\psi_{NO} \geq \psi_{SO}$

In a headquarter-intensive sector given the ranking of fixed costs specified in (2), four production modes can exist, as depicted in Figure 2. There are four productivity cutoffs determining the ranges of heterogeneous 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.[12]

[11] In headquarter-intensive sectors (i.e., η^h is large), both φ and ζ are increasing in ξ and $\varphi > \zeta$ except when ξ is very small.

[12] 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 $\Theta_{SO} = \frac{B\phi_{SO}}{\psi_{SO}}$, $\Theta_{SV} = \frac{B(\phi_{SV}-\phi_{SO})}{\psi_{SV}-\psi_{SO}}$, $\Theta_{NO} = \frac{B(\phi_{NO}-\phi_{SV})}{\psi_{NO}-\psi_{SV}}$, and $\Theta_{NV} = \frac{B(\phi_{NV}-\phi_{NO})}{\psi_{NV}-\psi_{NO}}$, where $B = w_N/D$.

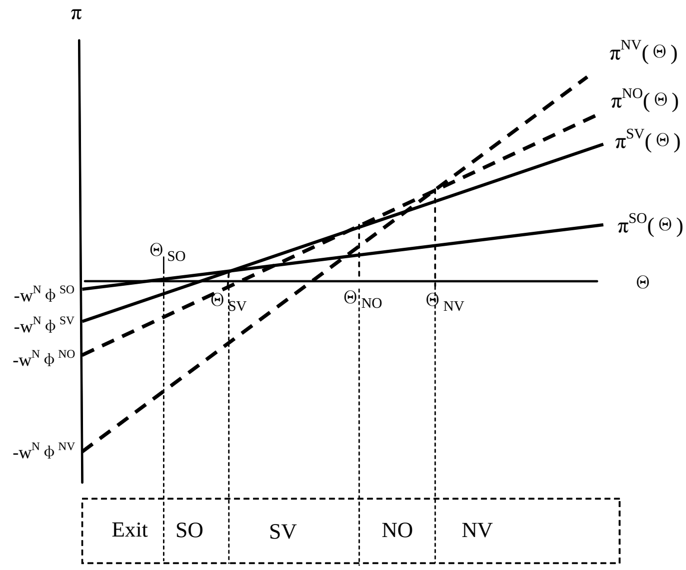

Figure 2: Headquarter-intensive sector

To guide our empirical analyses that examine the impact of headquarter intensity on the share of intrafirm trade in each trade regime, we now derive expressions for the fraction of firms choosing each production mode (SO, SV, NO, NV). 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 parameter κ, so that the cumulative distribution function of firm productivity is $G(\Theta) = 1 - \left(\frac{\Theta_{\min}}{\Theta}\right)^{\kappa}$ for $\kappa > 2$ and $\Theta \geq \Theta_{\min} > 0$. In an assembly-intensive sector, no firms chooses integration and the fraction of intrafirm trade is 0. In a headquarter-intensive sector we have the following expressions for the share of firms in each production mode:

$$\begin{aligned} S_{SO} &= 1 - \left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}, \\ S_{SV} &= \left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa} - \left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa}, \\ S_{NO} &= \left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa} - \left(\frac{\Theta_{SO}}{\Theta_{NV}}\right)^{\kappa}, \\ S_{NV} &= \left(\frac{\Theta_{SO}}{\Theta_{NV}}\right)^{\kappa}. \end{aligned} \tag{6}$$

From equation (7) we obtain the fraction of integrated firms within the import-and-assembly regime as

$$\frac{S_{SV}}{S_{SO} + S_{SV}} = 1 - \left[1 - \left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}\right] / \left[1 - \left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa}\right].$$

Since Θ_{SV}/Θ_{NO} increases with ψ_{NO}/ψ_{SV}, which in turn increases with headquarter intensity, η^h, as long as both organizational forms exist under import-and-assembly, the share of integrated firms within import-and-assembly is higher in sectors with higher values of η^h.This positive relationship between the share of intrafirm trade and the intensity of headquarter inputs is consistent with the main prediction of Antràs (2003).

The fraction of integrated firms within the pure-assembly regime is given by

$$\frac{S_{NV}}{S_{NV}+S_{NO}} = \left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{\kappa}.$$

The ratio $\frac{\Theta_{NO}}{\Theta_{NV}}$ may increase or decrease with headquarter intensity, η^h.[13] Therefore, the impact of η^h on the composition of firms across the two organizational forms within pure-assembly is ambiguous. This ambiguous relationship between the share of intrafirm trade and the intensity of headquarter inputs for the pure-assembly regime is particular to our model which is motivated by the existence of two trade regimes for export processing in China.

To better understand this result, 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 depends on which productivity cutoff is more responsive to the headquarter-intensity change.

In the rest of the paper, we use detailed product-level export data for China to examine the prevalence of intrafirm trade versus outsourcing across industries in the two trade regimes for export processing in China, import-and-assembly and pure-assembly.

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 6-digit classification (example of a product: 611241 - 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. "Processing and Assembling" and "Processing with Imported Materials"). The data also reports quantity, quantity units, customs offices (ports) where the transaction was

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

processed (97 in total), and transportation modes. In this paper we use data for processing trade which is classified according to the special customs regimes "Processing and Assembling" (pure-assembly) and "Processing with Imported Materials" (import-and-assembly). Regular trade is classified by the China Customs Statistics according to the regime "Ordinary Trade".

Skill, material, capital, capital-equipment and capital-plant intensities are constructed using data from the Bartelsman and Gray (1996) data base for 2002.[14] 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 $\mathrm{K}_i/\mathrm{L}_i$, skill-intensity $\mathrm{H}_i/\mathrm{L}_i$, material intensity $\mathrm{M}_i/\mathrm{L}_i$, capital-equipment intensity $\mathrm{E}_i/\mathrm{L}_i$ and capital-plant intensity $\mathrm{P}_i/\mathrm{L}_i$. Capital intensity (total capital, capital-equipment and capital-plant) is measured as the natural log of the corresponding capital expenditures divided by all worker wages. Material intensity $\mathrm{M}_i/\mathrm{L}_i$ is measured as the log of material expenditures divided by workers wages. Skill intensity $\mathrm{H}_i/\mathrm{L}_i$ is the log of non-production worker wages divided by total worker wages. As a robustness check, we construct measures of capital and skill intensity using Chinese plant-level data on capital and workers with 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 use the 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 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 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

[14] 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.

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.[15] We use the US productivity dispersion measure as the decision on the organizational form is made by the headquarters of the firm in the developed country. We believe that the measure for the U.S. is a good proxy for productivity dispersion measures in other developed countries. As a robustness check, 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 Empirical Analysis

5.1 Testable Hypothesis

In this section, we use detailed product-level export data for China to examine the prevalence of intrafirm trade versus outsourcing across industries in the two trade regimes for export processing in China, import-and-assembly and pure-assembly. We investigate the following hypothesis.

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 is about the relationship between industry productivity dispersion and the share of intrafirm trade. 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

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

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 organization mode.

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. On the one hand, the improvement in the contractibility of inputs implies more tasks being contractible ("Standard Effect"). 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 ("Surprise Effect").

(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.

5.2 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 intensity 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:

$$\frac{X_j^{lV}}{X_j^{lV}+X_j^{lO}}=\gamma_H\frac{H_j}{L_j}+\gamma_K\frac{K_j}{L_j}+\gamma_M\frac{M_j}{L_j}+\epsilon_j, \tag{7}$$

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 l that are accounted for by foreign affiliates. We use this ratio as our measure of intrafirm trade based on the assumption that assembly plants under an export-processing regime assemble intermediate inputs into final goods for their foreign owners.[16] For the proxies for headquarter intensity, we use the log of non-production worker wages to total worker wages, H_j/L_j and the log of the real value

[16] 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 headquarters.

of capital stock to the total wage bill, K_j/L_j. Material intensity M_j/L_j is the log of the cost of materials divided by total worker wages.[17]

Our model predicts that intrafirm trade should account for a larger share of exports in the more headquarter-intensive sectors under the import-and-assembly regime (this prediction is consistent with existing models), 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 (7) 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 a 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 Bernard, Jensen, Redding and Schott (2008), Nunn and Trefler (2008) and Yeaple (2006), 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.

For import-and-assembly exports, the coefficients on capital intensity are negative and statistically significant, in contrast with 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 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 only the coefficient on plant intensity, the type of capital that is supposed to have a higher outside value, is negative and statistically significant. The coefficient on equipment intensity, on the other hand, is found to be positive but statistically insignificant.

Let us now turn to the results for pure-assembly reported 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

[17] 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.

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 analysis of Table 4 at the HS 6-digit product level. Because our regressors of interest only vary across SIC 4-digit industries, the 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 statistically significant relationship between the share of intrafirm trade and skill intensity for the import-and-assembly exports (the coefficients on skill intensity are statistically significant at the 1% level), consistent with the results in Table 4. No statistically significant results are found for the pure-assembly regime.

The regression exercises above examine export shares aggregated across different importing countries within the same sector. The results may therefore hide substantial differences across importing countries, as well as differences in the relationship between China and these countries, such as distance, institutional and endowment differences. To take these differences into account, we repeat the analysis in Table 5 but using unilateral export volume in a HS-6 digit category to each importing country as the unit of observation. Since our focus is on the sectoral determinants of intrafirm trade, instead of examining the impact of these countries' characteristics on intrafirm trade, we control 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 model does not formally discuss the relationship between material intensity and intrafirm trade, we can still use insights from the property-rights approach to explain the relationship. Under import-and-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 organization mode.

For pure-assembly (columns (4) to (6)), we find more statistically significant results compared to the previous analyses at the SIC-4 and HS-6 levels. It is perhaps surprising to find a negative and significant coefficient on skill intensity. 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.

So far, we have examined 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 statistically significant coefficients on skill intensity across all country samples. If we restrict exports to 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). The results are similar to those obtained in Table 6. Importantly, we find a significantly positive relationship between capital-equipment 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. In column (6) we exclude exports to Hong Kong from the sample. This is to address the concern that some foreign-owned plants may have their headquarters in Hong Kong, who serve as intermediaries to re-export final products to foreign clients. The results are similar to those for the full sample of countries. 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 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, although 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 the ranking of these measures is stable across countries. Although this approach has been widely adopted in previous empirical studies,[18] to check the robustness of our results we also use factor intensity measures constructed using Chinese plant-level data. Due to data limitation, the definition of these measures is not exactly the same as the US-based measures. Capital intensity is defined as 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

[18] The approach of using sector measures constructed using U.S. data originates from Rajan and Zingales (1998). Subsequent empirical studies on countries' comparative advantage have adopted the same approach. See Romalis (2003), Levchenko (2007), Nunn (2008) and Manova (2007), among others.

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 product, or disaggregated exports at the country-product 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.

5.3 Examining the Effects of Productivity Dispersion

This section investigates 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 exhibits 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 to examine Hypothesis 2:

$$\frac{X_{jc}^{lV}}{X_{jc}^{lV}+X_{jc}^{lO}} = d_c + \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \delta_\theta \sigma_j^\theta + \delta_{\theta\eta}\sigma_j^\theta \eta_j + \epsilon_{jc}, \tag{8}$$

where η_j is a measure of one of the factor intensities: skill, capital, equipment or plant. We control for importer heterogeneity by allowing for country fixed effects, d_c. 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 (8) in Table 10. We include all stand-alone headquarter intensity measures as controls. We 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 import-and-assembly, we do not find any relationship between sectoral productivity dispersion and the share of intrafirm trade. In particular, while the coefficient on the stand-alone dispersion term is positive and statistically significant when capital and equipment capital intensities are used for η_j, the coefficients on the interaction terms are now negative and statistically significant in columns (2) and (3).

For pure-assembly, the results reported in columns (4) and (6) show that when skill- or equipment-intensity is interacted with σ_j, the estimated coefficients on both the dispersion and the interaction term are positive and statistically significant (at the 1% level). When we use capital intensity for η_j, we continue to find a strongly positive coefficient on the interaction term, but not on the stand-alone dispersion term. Therefore, the estimated relationship between productivity dispersion and the share of intrafirm exports is higher in sectors with a higher headquarter intensity. In sum, we find evidence supporting Hypothesis 2 for the pure-assembly regime. 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 productivity 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 intensity is used to proxy for headquarter intensity. In particular, for pure-assembly the estimated relationship between productivity dispersion and the share of intrafirm trade is higher in sectors with a higher skill intensity. When capital-equipment is used to proxy for 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 significant. Furthermore, when we use Chinese manufacturing firm sales to construct our dispersion measure, 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 is 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 prediction 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. We define headquarter intensity quintile dummies as $I^{\eta}_{jp} = 1$ if industry j is in quintile p, $p = 1$ being the least headquarters-intensive quintile. We estimate equation (9) 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.

$$\frac{X^{lV}_{jc}}{X^{lV}_{jc} + X^{lO}_{jc}} = d_c + \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \sum_{p=1}^{5} \delta_{\eta p} I^{\eta}_{jp} + \sum_{p=1}^{5} \delta_{\theta\eta p} (\sigma^{\theta}_j * I^{\eta}_{jp}) + \epsilon_{jc}, \tag{9}$$

The results are reported in Table 12. Columns (1) through (5) report results for import-and-assembly, 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 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. Regarding exports under import-and-assembly, we find no significant relationship between productivity dispersion and the share of intrafirm exports (in columns (3) to (5)). These results are consistent with the findings of Table 10.

5.4 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 the degree of which the investments in these inputs are contractible are important determinants of vertical integration by multinationals. Holding headquarter intensity constant, an increased contractibility of the 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 for 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 preferred even in sectors with a lower headquarter intensity. If the "Surprise Effect" dominates the "Standard Effect", the share of intrafirm trade increases with the contractibility of inputs. To examine Hypothesis 3, we estimate the following equation:

$$\frac{X_{jc}^{lV}}{X_{jc}^{lV}+X_{jc}^{lO}} = d_c + \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \delta_Z Z_j + \delta_{Z\eta} Z_j \eta_j + \epsilon_{jc}, \tag{10}$$

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 the measure of contractibility from Nunn (2007), which equals one minus the share of intermediate inputs for production in a sector that are not sold on an 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 (10) for a sample of unilateral exports to each country in a HS-6 category. Headquarter intensity measures are always controlled for. For import-and-assembly exports, when capital and equipment intensities are used to measure 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 pure-assembly. 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 (2008) 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 investigation 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 (11) 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.

$$\frac{X_{jc}^{lV}}{X_{jc}^{lV}+X_{jc}^{lO}} = d_c + \gamma_H \frac{H_j}{L_j} + \gamma_K \frac{K_j}{L_j} + \gamma_M \frac{M_j}{L_j} + \sum_{p=1}^{5} \delta_{\eta p} I_{jp}^{\eta} + \sum_{p=1}^{5} \delta_{Z\eta p}(Z_j * I_{jp}^{\eta}) + \epsilon_{jc}, \tag{11}$$

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 quintile of headquarter-intensive sectors. In particular, the coefficient on the interaction between the 5th quintile dummy and the contractibility measure is negative and statistically significant when capital and equipment-capital intensities are used as proxies for headquarter intensity. For pure-assembly (columns (4) to (6)), no significant relationship is found.

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 is 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. 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 uses detailed product-level export data for China to investigate the determinants of integration versus outsourcing. We exploit the coexistence of two regulatory trade regimes for export-processing in China, pure-assembly and import-and-assembly. Under import-and-assembly Chinese plants have control rights and ownership over the imported materials. Under pure-assembly, ownership over the materials shipped to China, remains with the foreign firm. We present an extension of the Antràs and Helpman (2004) framework 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.

Our empirical results show that when Chinese plants import materials from abroad and assemble them, 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 are consistent with existing theories. However, if Chinese plants engage in pure-assembly, under which regime ownership over the materials shipped to China remains with the foreign firm, we find little support for existing theories on intrafirm trade that focus on the contract incompleteness and the relative importance of relationship-specific investments.

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. This set 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 for the import-and-assembly regime but not for the pure-assembly regime.

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A Appendix

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, H maximizes her expected operating profits as:

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

Under pure-assembly, A's maximization problem is

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

For a given organizational form $k \in \{V, O\}$, 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

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

Plug these investment functions into the joint profit function of the firm, we obtain firm operating profit as $\pi_{Nk} = D\Theta\psi_{Nk} - w^N \phi_{Nk}$, where $\Theta \equiv \theta^{\frac{\alpha}{1-\alpha}}$, ϕ_{Nk} is the fixed cost associated with organization mode k under pure-assembly, and

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

The function ψ_{Nl} reaches its maximum when $\frac{d\psi_{Nk}}{d\beta_{Nk}} = 0$. 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 $\omega\left(\eta^h\right) = 1 - \overline{\eta}^m - \eta^h$.

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:

$$\max_h \beta_{Sk} R(m,a,h) - w^N h$$

A's maximization problem is

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

For a given organizational form $k \in \{V, O\}$, solving the first order conditions of the headquarter's problem and the assembly plant's problem simultaneously give the following profit-maximization investment levels:

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

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

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

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

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

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

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

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	1,363	3,394	2,302	2,482	2,402	3,347
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	2,689	1,585	1,743	1,524	2,479
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	3,505	72,177	2,770	34,624
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)

	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
	(1)	(2)	(3)	(4)	(5)	(6)
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)

	Import-and-assembly			Pure-assembly		
Headquarter intensity measure:	skill	capital	equipment	skill	capital	equipment
	(1)	(2)	(3)	(4)	(5)	(6)
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	72,030	72,030	72,030	34,551	34,551	34,551
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	71,966	71,966	71,966	71,966	71,966	34,541	34,541	34,541	34,541	34,541
No. clusters	347	347	347	347	347	329	329	329	329	329
R^2	.077	.092	.082	.082	.085	.030	.120	.110	.100	.120

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	58,587	58,587	58,587	26,158	26,158	26,158
No. Clusters	282	282	282	265	265	265
R^2	.091	.094	.099	0.100	0.110	0.100

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.

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	15,443	15,443	15,443	9,207	9,207	9,207
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.
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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	0.040

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	63,368	63,368	63,368	31,041	31,041	31,041
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.