HONG KONG INSTITUTE FOR MONETARY RESEARCH

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HKIMR Working Paper No.05/2010

March 2010

The Determinants of Vertical Integration in Export Processing: Theory and Evidence from China*

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March 2010

Abstract

This paper uses detailed product-level export data for China and proposes an extension of the Antràs and Helpman (2004) framework that includes investments in component search to investigate the determinants of foreign direct investment (FDI) versus foreign 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 exports from vertically integrated plants 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 the existing theories on FDI and outsourcing that focus on contract incompleteness and the relative importance of relationship-specific investments. We also find that more dispersed firm productivity in a sector is associated with a larger export share of integrated plants under pure-assembly but not under import-and-assembly. These results are consistent with the predictions of our model, which focuses on ownership of imported components as an alternative to asset ownership for alleviating the hold-up problem by the export-processing plant.

Keywords: Intrafirm Trade, Vertical Integration, Export Processing, Outsourcing

JEL Classification: F14, F23, L14, L33

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* We are grateful to Giovanni Facchini, Emanuel Ornelas, Larry Qiu, Shang-Jin Wei, Stephen Yeaple and seminar participants at Clark, Colby College, LSE, Nottingham, Sussex and Trinity College Dublin, as well as conference participants at the First Meeting of Globalization, Investment and Services Trade in Milan, the 2009 SAET Conference in Ischia and the 2009 ETSG Conference in Rome for insightful discussions and comments. We thank Randy Becker, Joseph Fan, Nathan Nunn and Peter Schott for kindly sharing with us their data. We also thank Nuffield Foundation for financial support.

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1. Introduction

This paper uses detailed product-level trade data from China's Customs and proposes an extension of the Antràs and Helpman (2004) framework that includes investments in component search to study the relative prevalence of FDI versus outsourcing in export processing trade. Motivated by the substantial growth in foreign affiliate sales, an expanding theoretical literature adopts approaches from the theory of the firm to study the determinants of intrafirm trade.[1] However, empirical evidence is relatively scant and exclusively focuses on the developed world. Export processing plants in China operate under two regulatory regimes, which differ in the allocation of ownership and control rights over imported materials. By exploiting the coexistence of the two regimes that are unique to China, we add to the empirical literature on validating the predictions of the theoretical models on contracting, organizational structure and international trade. In particular, we examine various determinants of FDI and arm's-length trade across industries from the perspective of the input suppliers and assembly plants in a rapidly developing country. Our results complement the existing empirical literature that has so far focused on the headquarter's side in developed countries.

Export processing has been an important part of China's economic development. It accounted for more than half of its exports in recent years. To promote export-led growth, the Chinese government offers tariff exemption on imported materials for export-processing plants, as long as the entire output is exported. Export-processing plants in China have been governed under two regulatory regimes since the early 1980s, which are referred to as 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 inputs. Specifically, under the pure-assembly regime, a foreign firm supplies components to a Chinese plant who processes them into finished products. The foreign firm retains ownership of the imported inputs throughout the production process. Under the import-and-assembly regime, on the other hand, an assembly plant in China imports inputs of its own accord. The assembly plant owns the inputs and reserves the option of using the imported inputs for export processing for other foreign clients.

We exploit this special regulatory feature in China to better understand the prevalence of FDI versus outsourcing. The premise is that different allocation arrangements of control rights and ownership of imported inputs across the two trade regimes can affect the organizational choices of the foreign clients, and thus shape the pattern of trade across industries. To guide our empirical analysis on the organizational structure of trade flows and deepen our understandings of export processing, we extend the Antràs and Helpman (2004) North-South trade model with heterogeneous firms to incorporate investments in input search by the joint production unit. The extension involves the final-good producer in the North searching for inputs internationally under pure-assembly; whereas the assembly plant in the South conducts the search under import-and-assembly. When the terms of

[1] Seminal work includes McLaren (2000), Antràs (2003, 2005), Grossman and Helpman (2002, 2003, 2004, 2005), Antràs and Helpman (2004, 2008). See Helpman (2006) for a summary of the theoretical literature, and Hummels *et al.* (2001) for the evidence of the tremendous growth of trade in intermediate inputs. More recent studies include Conconi *et al.* (2009) and Ornelas and Turner (2009), among others.

investments cannot be fully specified in contracts ex ante, both parties of the joint production unit anticipate Nash bargaining over the surplus from the relationship, and underinvest in their corresponding activities as in the classic hold-up situation à la Grossman and Hart (1986). When control and ownership over imported inputs give the owners an outside option to use the inputs or the associated intangible asset with a third party when bargaining breaks down, the optimal organizational structure may involve allocating ownership of both the imported inputs and the plant's assets to the party whose investments are more important for production.

Our heterogeneous-firm model predicts the coexistence of vertical integration and outsourcing in both import-and-assembly and pure-assembly regimes in a sector for which headquarter investments are sufficiently important. Under import-and-assembly, the export share of integrated firms is increasing in headquarter intensity across sectors, consistent with predictions by Antràs (2003). Under pure-assembly, the relationship between sectoral headquarter intensity and the prevalence of integration is ambiguous. The reason is that when expected hold-up by the assembly plant intensifies, a foreign client can choose to either own imported inputs or the plant's assets to alleviate the hold-up problem. The optimal organizational structure depends on whether the relative gain of owning assets is larger than that of owning imported inputs or not. Under these circumstances, when headquarter investments become more important, some firms switch from import-and-assembly to outsourcing under pure-assembly, while some firms switch from outsourcing to integration within the pure-assembly regime. The net impact on the composition of organizational structures in the pure-assembly regime would depend on the sensitivity of the two “switching” margins to a change in headquarter intensity.

We examine these theoretical predictions using detailed product-level trade data collected by China's Customs. In particular, for each trade regime, we regress the share of exports from vertically integrated plants in total exports at the HS 6-digit level on various measures of the intensity of headquarters inputs. For the import-and-assembly regime, we find a positive relationship between the share of integrated plants' exports and the intensity of headquarters inputs (skill, R&D and capital-equipment). 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 integrated plants' exports. For the same regime, we find evidence that productivity dispersion and the export share of integrated plants are positively correlated across sectors. These results are consistent with the baseline case of our model when only the most productive firms integrate with assembly plants under pure-assembly.

In the incomplete contracting framework, besides headquarter intensity, the degree to which investments are contractible is an important determinant of foreign firms' integration decisions. Antràs and Helpman (2008) introduce partial contractibility of investments to their baseline model (Antràs and Helpman, 2004), which yield ambiguous effects of an improvement in contractibility of investments on the propensity to integrate. We examine the effects of contractibility of investments across sectors, and find that in industries with higher values of headquarter intensity, an increase in contractibility of the supplier's inputs is associated with a lower share of exports from integrated plants under import-and-assembly.

Using data from a developing country, our paper complements the existing empirical studies on the determinants of arm's-length trade versus FDI in developed countries. Yeaple (2006), Bernard, Jensen, Redding and Schott (2008), and Nunn and Trefler (2008a,b) provide sector-level evidence for the U.S. These studies find empirical support for the predictions of existing models based on the property-rights approach. 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. Their findings are both consistent with Antràs and Helpman (2004), but require different assumptions about the ranking of fixed costs associated with different organizational structures.

In all of these studies, imports within multinationals' boundaries are assumed to be shipped from foreign subsidiaries to the headquarters. However, it has been pointed out that a significant share of the intrafirm imports originates from the foreign headquarters of the U.S. subsidiaries, especially from rich countries (Nunn and Trefler, 2008). Our paper considers exports from export-processing assembly plants who produce solely for sales in the countries where the headquarters are located. By focusing on exports from the subsidiaries to the multinational headquarters, cleaner results can be obtained to validate the existing theoretical models, which have so far placed sourcing decisions by the headquarters in the North at the center of analysis.

Our paper is closely related to Feenstra and Hanson (2005) who also study choices of production modes by foreign firms in the two export processing regimes in China. In particular, they investigate both theoretically and empirically the prevalence of foreign ownership in the import-and-assembly regime in China. We instead focus on the sectoral determinants of vertical integration in each trade regime.

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 hopes of obtaining foreign technology, boosting employment and economic growth, China implemented various policies to promote exports and foreign direct investments since the early 1980s when economic reforms started. One of the key policies is to provide tax incentives to encourage export-processing trade, which has been regulated by China's Customs under two regimes: pure-assembly and import-and-assembly.[2] Since then, export processing has been a main driver of the impressive growth of China's foreign trade. Table 1 shows that export processing accounted for about 55 percent of the volume of total exports from China in 2005, and more than 80 percent of foreign-invested enterprises' exports. Among export-processing trade, import-and-assembly is more prevalent. As Table 1 shows, 78 percent of export-processing exports was from the import-and-assembly regime, under which the Chinese assembly plants retain ownership over imported inputs. Of these import-and-assembly exports, 76 percent was exported from the foreign-invested plants. Of the pure-assembly exports, on the other hand, foreign affiliates accounted for about 44 percent. In short, foreign ownership is more prevalent in the import-and-assembly regime, compared to pure-assembly, as is pointed out by Feenstra and Hanson (2005).

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

Under import-and-assembly, the Chinese plant plays a more active role. Instead of passively receiving materials from the foreign client, an assembly plant searches for intermediate inputs for assembly processing. Importantly, the assembly plant retains ownership of the imported inputs throughout the production process. Different from a pure-assembly plant, it may purchase the same kind of inputs and use them with multiple foreign firms. To obtain permission to trade under this regime, assembly plants need to maintain a higher standard of accounting practices and warehouse facilities, relative to a pure-assembly plant. Application for operating a plant under import-and-assembly is generally more difficult. Plants are required to make investments in warehouse facilities, inventory and accounting systems (Feenstra and Hanson, 2005).

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, and therefore its investments in human capital. Under pure-assembly, the main role of a Chinese manager is 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 maintain a high standard of warehouse facilities and accounting systems.

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2 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.

3 Readers are referred to Naughton (1996) and Feenstra and Hanson (2005) for a more detailed description about the two regulatory regimes.

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 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 higher. The third difference has to do with the approval standard. Since import-and-assembly plants are allowed to use domestic inputs together with the imported ones for production, getting approval is generally more difficult. Certain accounting procedures have to be consistently maintained, as value-added taxes can potentially be rebated for inputs that are entirely used for exports. Importantly, transition from one regime to another is quite costly under these circumstances.

3. A Theoretical Model

3.1 Model Setup

To guide our empirical analysis that involves four production modes, we extend the North-South trade model with heterogeneous firms by Antràs and Helpman (2004). Specifically, we include investment decisions for component search activities in processing trade. At a conceptual level, ownership of components should have similar "incentivizing" effects provided by asset ownership. Our theoretical model aims at providing a formal analysis of the determinants of the organizational structure of multinational production when ownership of imported inputs and the plants' assets are to be chosen.

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 following 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 firm's sector; and α is a parameter that determines the demand elasticity of the brand.[4]

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 to the following production function:

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

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

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.

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

where θ is firm productivity, $0 < \eta^m < 1$, $0 < \eta^a < 1$ and $\eta^h = 1 - \eta^m - \eta^a$.[5] 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 invests only 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, $\lambda' s$ are assumed to be identical across trade regimes.

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, reflecting what the Chinese government requires export-processing plants to do. A 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 an 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 firm productivity θ. If the expected operating profits are negative, she exits the market; otherwise, she chooses one of the four production modes. Different fixed costs are incurred depending on the choice of production mode. 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 the type of trade regime H chooses ex ante. After the production of inputs, H and A bargain over the division of surplus in a Nash bargaining game. If they agree to continue the relationship, components m are shipped from abroad to A, which are then assembled with assembly inputs a to produce finished products. Finally, the finished products are exported to H in the North for sales, which require headquarter services h.

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 primitive bargaining power of H, and with $1 - \beta$ being the primitive bargaining power of A.

5 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 FDI across sectors that are specific to export processing in China. Based on the demand function specified above, 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 depends on both the organizational form (V or O) and the trade regime (N or S). Different outside options in turn affect the de-facto shares of the surplus between the foreign firm and the assembly plant. We now discuss the resulting surplus distribution under different production modes.

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.[6]

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. Suppose H's investments are completely specific to A. H's outside option is also 0.[7]

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

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

6 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 insight of the paper is independent of the assumption of complete specificity.

7 Antràs and Helpman (2008) allow for partial specificity, which we will allow in our regression analysis.

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

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

3.2.2 Import-and-Assembly

We now turn to the analysis of the ex post distribution of 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 A, 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 focus on internal solutions and assume that $\gamma + \delta^\alpha < 1$.

If H chooses outsourcing, she has no ownership of either A's assets or components. Her outside option will be equal to 0, while A's outside option will be γR, similar to the case of integration under import-and-assembly. Let us denote H's expected payoff under integration and outsourcing within this regime by $\beta_{SV}R$ and $\beta_{SO}R$, respectively. The dependence of the outside options on the organization modes implies

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

Notice 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

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

3.2.3 Choosing Optimal Production Modes

If fixed costs are all identical, the model predicts that all foreign firms choose outsourcing in assembly-intensive sectors (high η^a), and integration in headquarter-intensive sectors (high η^h).[8] However, we observe different organizational forms across sectors from the data. Moreover, in practice, different organizational modes appear to be associated with different set-up costs. We now consider fixed costs of production that vary across production modes.

We assume that H has to incur an identical fixed cost of entry ϕ (in terms of North's labor). Conditional on productivity that is sufficient to guarantee non-negative expected operating profits, H chooses a trade regime (N or S) and an organizational form (V or O) for its operation. 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., $g_N > g_S$). This assumption requires that establishing a logistic and transport network between the assembly plant and its overseas supplier involves a significant fixed cost.[9] Moreover, we assume that overhead costs of transporting tangible goods are higher than those associated with managing a subsidiary (i.e., $g_N > f_V$) for our baseline analysis. Denoting the fixed costs of production mode kl by $\phi_{kl} = f_k + g_l + \phi$, our assumptions imply the following ranking of total fixed costs:[10]

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

8 If we derive the optimal β_{lk}^* that maximizes joint surplus (solving $\frac{d\psi_{lk}}{d\beta_{lk}} = 0$ for $\in \{N, S\}, k \in \{V, O\}$) we obtain the following. Under import-and-assembly, $\beta_{SV} > \beta_{SO} > \beta_S^*(\eta^h)$ for an assembly-intensive sector, which implies $\psi_{SO} > \psi_{SV}$. Similarly, under pure-assembly, $\beta_{NV} > \beta_{NO} > \beta_N^*(\eta^h)$ for an assembly-intensive sector, which implies $\psi_{NO} > \psi_{NV}$.

9 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 sufficient to offset the cost saving from decentralization of component purchasing.

10 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.

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:

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

Recall that through asset ownership, vertical integration always enhances the effective share of surplus in a given regime (i.e., $\beta_{NV} > \beta_{NO}$ and $\beta_{SV} > \beta_{SO}$). Across regimes, the ranking of the de facto shares 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 plants in developing countries, the plant's manager plays a critical role in managing and coordinating local staff. Component ownership is an important determinant of the owner's outside option. Based on these arguments, we focus on the following ranking of the $\beta' s$ as our baseline case:[11]

$$\beta_{NV} > \beta_{NO} > \beta_{SV} > \beta_{SO} \qquad (3)$$

The final-good producer's choices depend on ψ's and the fixed costs ϕ's associated with different production modes. Let us now turn to the discussion of the ranking of ψ's. As outsourcing 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 an assembly-intensive sector. 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 if and only if final-good producers command a sufficiently large cost advantage over component search (i.e., $\psi_{NO} > \psi_{SO}$). Readers are referred to the appendix for a formal analysis on the conditions under which this inequality holds.

Importantly, in an assembly-intensive sector, if $\psi_{NO} > \psi_{SO}$, more productive firms would choose pure-assembly whereas the less productive ones would choose import-and-assembly because of the latter's lower fixed costs. Figure 1, which plots firm profits against firm productivity term $\theta^{\frac{\alpha}{1-\alpha}}$, illustrates such a scenario under the ranking of fixed costs specified in (2). On the other hand, if assembly plants command a sufficiently large cost advantage over component search, $\psi_{SO} > \psi_{NO}$, import-and-assembly is the only prevalent production mode.

In a headquarter-intensive sector, both integration and outsourcing can be optimal organization modes. Since control and ownership over the components give H extra incentive to invest in headquarter services, pure-assembly is associated with a higher ψ than import-and-assembly. Inequality (3) is then translated into $\psi_{NV} > \psi_{NO} > \psi_{SV} > \psi_{SO}$. Together with the ranking of fixed costs specified in (2), four production modes can coexist, as depicted in Figure 2. There are four productivity cutoffs determining the ranges of heterogeneous firms operating in different production modes. Firms with productivity term $\theta^{\frac{\alpha}{1-\alpha}}$ below Θ_{SO} exit, those with productivity parameter between

11 It is important to note that our testable hypotheses are independent of the assumption that $\beta_{NO} > \beta_{SV}$. We make this assumption to obtain more tractable comparative statics.

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. See the appendix for the expressions of these cutoffs.

To guide our empirical analyses, we now derive the expressions of the export share of integrated plants under each trade regime. To obtain closed-form expressions of these shares, we follow Helpman, Melitz and Yeaple (2004) to assume that Θ is distributed Pareto with shape parameter κ, with a cumulative distribution function equal to $G(\Theta) = 1 - \left(\frac{\Theta_{\min}}{\Theta}\right)^{\kappa}$, where $\kappa > 2$ and $\Theta \geq \Theta_{\min} > 0$. Since no firms choose integration in an assembly-intensive sector, the market share of integrated exports is 0.

In a headquarter-intensive sector, the export value from each of the four production modes is positive under the benchmark case. In particular, total export volume of a headquarter-intensive sector is

$$X = D[\psi_{SO}V(\Theta_{SO},\Theta_{SV}) + \psi_{SV}V(\Theta_{SV},\Theta_{NO}) + \psi_{NO}V(\Theta_{NO},\Theta_{NV}) + \psi_{NV}V(\Theta_{NV},\infty)]$$

where

$$V(A,B) = \int_A^B \Theta dG(\Theta) = \Gamma(A^{1-\kappa} - B^{1-\kappa})$$

where $\Gamma = \frac{\kappa\Theta_{\min}^{\kappa}}{\kappa-1}$.

Under import-and-assembly, the export share of integrated assembly plants can be expressed as (see appendix for details):

$$\frac{X_{SV}}{X_{SO}+X_{SV}} = \left[1 + \frac{\psi_{SO}}{\psi_{SV}} \frac{1-\left(\frac{\theta_{SV}}{\theta_{SO}}\right)^{1-\kappa}}{\left[\left(\frac{\theta_{SV}}{\theta_{SO}}\right)^{1-\kappa} - \left(\frac{\theta_{NO}}{\theta_{SO}}\right)^{1-\kappa}\right]}\right]^{-1} \tag{4}$$

In sufficiently headquarter-intensive sectors when all four production modes exist, $\psi_{lV}/\psi_{lO} > 1$ and is increasing in η^h for $l \in \{N,S\}$ (see Antràs, 2003). Similarly, with the assumption that $\beta_{NO} > \beta_{SV}$, $\psi_{NO}/\psi_{SV} > 1$ and is increasing in η^h for $l \in \{N,S\}$. As such, under import-and-assembly, the market share of integrated assembly plants exports is increasing in η^h. This positive relationship is consistent with the main prediction of Antràs (2003).

Under pure-assembly, the export share of integrated assembly firms is given by (see appendix for details):

$$\frac{X_{NV}}{X_{NV}+X_{NO}} = \left[1 + \frac{\psi_{NO}}{\psi_{NV}}\left[\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{1-\kappa} - 1\right]\right]^{-1} \quad (5)$$

It is shown in the appendix that under pure-assembly, the relationship between the export share of integrated assembly plants and headquarter intensity is ambiguous. The main determinant of the sign of the relationship is the respective change in the productivity cutoffs Θ_{NO} and Θ_{NV}. To understand the intuition of the ambiguity, consider a hypothetical exercise that production technology of a sector becomes more headquarter-intensive. On the one hand, the relatively more productive headquarters in the North who used to integrate with their assembly plants under import-and-assembly would switch to outsourcing under pure-assembly. On the other hand, the relatively more productive final-good producers in the North who used to outsource their production under pure-assembly would switch to integration within the same regime. Thus, the composition of export shares of the two organization modes under pure-assembly relies on the sensitivity of the margins of production modes to an increase in headquarter intensity of production. In particular, if the efficiency gains (due to changes in the incentives to invest) by obtaining ownership of the plant's assets are greater than the loss of giving up control rights of imported materials when η^h increases, the export share of integrated plants would increase (see appendix for details). This ambiguous relationship between the share of integrated plants' exports and headquarter intensity of inputs under pure-assembly is specific to our model, which is built to reflect the existence of two export processing regimes in China.

Our model predicts that in a headquarter-intensive sector, firms operating under pure-assembly are more productive than those under import-and-assembly. Moreover, only the most productive firms find it profitable to integrate with their assembly plants under pure-assembly, which involves the highest fixed cost among the four production modes. Regarding differences in heterogeneity across sectors, our model therefore predicts that when the distribution of firm productivity becomes more dispersed away from the lowest productivity in a sector (i.e., when κ decreases), the share of integrated plants' exports become more prevalent under pure-assembly, but not necessarily under import-and-assembly. See appendix for a proof.

These theoretical predictions lead to two testable hypotheses that we will investigate in the rest of the paper using detailed product-level export data for China to examine the prevalence of FDI versus outsourcing across industries in the two trade regimes, respectively.

Hypothesis 1: Headquarter Intensity and the Prevalence of FDI

Given the ranking of fixed costs of production as specified in (2), the share of exports of vertically integrated plants 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.

Hypothesis 2: Productivity Dispersion and the Prevalence of FDI

Given the ranking of fixed costs of production as specified in (2), in a headquarter-intensive sector, a higher sectoral productivity dispersion is associated with a larger export share of integrated plants' exports under the pure-assembly regime. Such relationship is absent in an assembly-intensive sector where integration is never a profit-maximizing organization mode.

4. Data

To examine the determinants of vertical integration in different trade regimes in China, 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 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 China Customs Statistics according to the regime "Ordinary Trade".

The measures of industry factor intensity are constructed using data from the Bartelsman and Gray (1996) data base, averaged across the period 2001-2005.[12] Following Nunn and Trefler (2008a,b), 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 $\ln(K_j/L_j)$, skill-intensity $\ln(H_j/L_j)$, material intensity $\ln(M_j/L_j)$, capital-equipment intensity $\ln(E_j/L_j)$ and capital-plant intensity $\ln(P_j/L_j)$. Capital intensity (total capital, capital-equipment and capital-plant) is measured as the natural log of the corresponding capital expenditures divided by all workers' wages. Material intensity is measured as the log of material expenditures divided by workers' wages. Skill intensity is the log of non-production worker wages divided by total workers' 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 the same definitions of factor intensities. Capital intensity is instead measured as the log ratio of the real value of capital to the real value of output for each sector. Human capital is the log of the share of high-school graduates in the sectoral workforce.

[12] We are grateful to Randy Becker from the U.S. Bureau of the Census for providing us with an updated version of the database.

We also include R&D intensity to proxy for headquarter's inputs. The data used to construct R&D intensity are from the Orbis database, which has information on around 60 million companies worldwide. The database is constructed by Bureau van Dijk Electronic Publishing. We measure R&D intensity, which we denote $\ln(RD_j/Q_j)$, by the natural log of global R&D expenditures divided by firm sales in each industry. The data are from the most recent year for which firm level data on R&D are available, either from 2006 or 2007. As robustness check, we also compute R&D and advertisement intensities using data obtained from the Chinese National Bureau of Statistics's Census of Industrial Production for 2005. R&D intensity is measured by the log ratio of R&D expenditure to value-added, while advertisement intensity is measured by the log ratio of advertisement expenditure to value-added. See data appendix for summary statistics.

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 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).

We also use the measure of industry productivity dispersion from Nunn and Trefler (2008a) for 2005. The construction of this measure follows Helpman *et al.* (2004); using firm sales as a measure of firm productivity, they construct estimates of the dispersion of firm productivity using the standard deviation of firm sales across all firms within an industry. Given the lack of firm-level data, Nunn and Trefler (2008a) 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*.[13] We use the US productivity dispersion measure, assuming that decisions on the organizational form of the production unit are usually made by headquarters in developed countries. We believe that the US-based measure is a good proxy for productivity dispersion in other developed countries. To check robustness of the results regarding productivity dispersion, we compute the standard deviation of export revenue across Chinese export-processing plants for each sector, based on a proprietary data set.

5. Empirical Analysis

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

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

5.1 Examining the Effects of Headquarter Intensity

Following the existing empirical literature on the determinants of intrafirm trade, such as Antràs (2003), Yeaple (2006) and Nunn and Trefler (2008a,b), we use skill and capital intensity as our proxies for the importance of headquarter services in production. We also include R&D intensity as an alternative measure of the importance of headquarter inputs. Furthermore, since we are interested in studying the decisions of integration by multinational firms under the two trade regimes under 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 start by estimating the following cross-industry regression for each trade regime separately at the HS 6-digit product level:

$$\frac{X_j^{lV}}{X_j^{lV}+X_j^{lO}} = \alpha + \gamma_H ln\left(\frac{H_j}{L_j}\right) + \gamma_K ln\left(\frac{K_j}{L_j}\right) + \gamma_M ln\left(\frac{M_j}{L_j}\right) + \varepsilon_j \quad (6)$$

where j stands for industry and 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. To proxy for headquarter intensity, we use the log ratio of non-production workers' wages to total wage bill, $\ln(H_j/L_j)$, and the log ratio of the real value of capital stock to the total wage bill, $\ln(K_j/L_j)$. Material intensity, $\ln(M_j/L_j)$, is the log ratio of the cost of materials to total wage bill.[14] α is a constant and the error term ε_j is assumed to be uncorrelated with the regressors. To check robustness, we use R&D intensity, $\ln(RD_j/Q_j)$, measured by the log ratio of global R&D expenditures to firm sales in each industry, as an alternative measure of headquarter inputs.[15]

Our model predicts that exports from vertically integrated plants should account for a larger share of exports in the more headquarter-intensive sectors under the import-and-assembly regime, but not necessarily under pure-assembly. Thus, the predicted signs of γ_H and γ_K are positive for the import-and-assembly sample.

Estimates of equation (6) for both trade regimes are shown in Table 3. We regress the share of integrated plants' exports in total exports on a number of measures of headquarter intensities. An industry is defined as a SIC-87 4-digit category. 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. In columns (1) through (4), we report results for the import-and-assembly regime. The standardized beta 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 0.121 and 0.137 standard-deviation increases in the share of integrated plants' exports,

[14] 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.

[15] Although conceptually R&D intensity is potentially a better measure, there are issues related with data availability and quality and therefore we use it for robustness checks.

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 (2008a) and Yeaple (2006), who find a positive relationship between skill intensity and the share of intrafirm trade across U.S. manufacturing industries. The size of the coefficients is at the same magnitude of those reported by Nunn and Trefler (2008a) 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 study by Nunn and Trefler (2008b), 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 (2008b) 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 and thus are associated with a higher outside value. 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 (more relationship-specific) intensity, $\ln(E_j/L_j)$, and plant-capital (less relationship-specific) intensity, $\ln(P_j/L_j)$ separately in the regressions. In column (3), we find that only the coefficient on plant intensity is negative and statistically significant. The coefficient on equipment intensity, on the other hand, is found to be positive but statistically insignificant.

Columns (2) and (4) report results when we include R&D intensity as an alternative measure of headquarter inputs. The Orbis database has R&D data for 370, 691 plants. We use data from the most recent year for which R&D firm level data are available, either 2006 or 2007. R&D intensity and skill intensity are highly correlated and therefore are not included as regressors simultaneously. Column (2) shows that the coefficient on R&D intensity is positive and statistically significant at the 10% level, and suggests that a one standard-deviation increase in R&D intensity is associated with a 0.069 standard-deviation increase in the share of integrated plants' exports. The coefficient on R&D intensity is no longer statistically significant when we include equipment-capital and plant-capital intensities separately in column (4).

Results for pure-assembly are reported in columns (5) to (8). We find in general no statistically significant relationships between the measures of headquarter intensity and the share of integrated plants' exports across sectors, with the exceptions of R&D intensity for which we find negative and statistically significant coefficients at the 5% level (columns (6) and (8)). These results are consistent with our theoretical prediction that the relationship between the prevalence of integrated plants' exports and headquarter intensity is ambiguous for pure-assembly exports. With firm heterogeneity, the number of firms choosing outsourcing and vertical integration increases under pure-assembly when headquarter intensity rises. The share of integrated plants' exports under pure-assembly, thus, can increase or decrease.

Since we are using export shares aggregated across different importing countries within the same product, the above results may mask substantial differences across importing countries, as well as differences in the relationship between China and these countries, such as differences in distance, institutional and factor endowments. To this end, we repeat the analysis by using unilateral export value in an HS 6-digit product category to each importing country as the unit of observation. Since our focus is on the sectoral determinants of the export share of integrated plants, we control for country fixed effects to parse out the effects of unobserved countries' characteristics. We therefore estimate the following regression:

$$\frac{X_{jc}^{lV}}{X_{jc}^{lV}+X_{jc}^{lO}} = d_c + \gamma_H ln\left(\frac{H_j}{L_j}\right) + \gamma_K ln\left(\frac{K_j}{L_j}\right) + \gamma_M ln\left(\frac{M_j}{L_j}\right) + \varepsilon_{jc} \quad (7)$$

where c stands for importing country and d_c is a set of country fixed effects. The dependent variable is the share of Chinese exports of an HS 6-digit good to country c under trade regime l that are accounted for by foreign affiliates. Table 4 reports the results. For the import-and-assembly regime (columns (1) to (4)), we find a positive and significant relationship between the share of integrated plants' exports and all measures of intensity of headquarter inputs (skill, R&D and capital-equipment). The coefficients suggest that a one standard-deviation increase in skill intensity is associated with between 0.168 and 0.191 standard-deviation increases in the share of integrated plants' exports, while a one standard-deviation increase in R&D intensity is associated with about a 0.1 standard-deviation increase in the share of integrated plants' exports. These coefficients are all statistically significant at the 1% level. We again obtain negative coefficients on capital intensity, but in column (3), we obtain a positive and statistical significant coefficient on the intensity of equipment, the more relationship-specific type of capital, and a negative and statistically significant coefficient on plant intensity, the type of capital that is less relationship-specific. These results support the theoretical prediction that a higher intensity of headquarter inputs, particularly those that are more relationship-specific, increases the export share of integrated plants under import-and-assembly.

A higher material intensity is found to have a negative impact on the integrated plants' export share (significant at the 5% level in column (3)). Although our theoretical model does not formally discuss the relationship between material intensity and the propensity to vertically integrate, 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 (5) to (8)), we find negative and significant coefficients on skill intensity and on R&D intensity. While these results should not be taken as a rejection of 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. In other words, ownership of imported materials can serve as a relatively less costly way to alleviate the hold-up problem by the assembly plant, compared with integration.

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 are reported in Table 5. For the import-and-assembly regime, 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 (0.222) is bigger than that for high-income countries (0.125). 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 in Table 4. In particular, we find a significantly positive relationship between capital-equipment intensity and the share of integrated plants' exports.

Columns (4) and (5) report consistent results using the samples of export to Japan and high-income European countries, respectively. 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 very 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. The lower part of the table reports results for the pure-assembly regime. The results for the different country groups are also consistent with those for the full sample reported in column (7) of Table 4.

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,[16] to check the robustness of our results, we use factor intensity measures constructed using Chinese plant-level data. Due to data limitation, the definition of these measures is not identical to the US-based measures. Capital intensity is defined as the log ratio of the average real value of capital to the average 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. R&D intensity is measured by the log ratio of R&D expenditure to value-added, while advertisement intensity is measured by the log ratio of advertisement expenditure to value-added. Table 6 reports the regression results using these Chinese-plant-based factor intensity measures. We obtain a positive and significant relationship between skill intensity, R&D and advertisement intensity, and the share of integrated plants' exports under import-and-assembly. The coefficients are significant at the 1% level and of similar magnitude for both measures of headquarters inputs. The results are independent of using samples at the HS 6-

[16] 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.

digit product level or at the country-product level. For pure-assembly exports, the sign of the coefficient on skill intensity turns negative, and those on capital intensity and R&D intensity become insignificant. These results are largely consistent with those obtained using US measures of factor intensity.

5.2 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 integrated plants' exports 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.* (2007a, 2007b), the top 1 (10) percent of the U.S. trading firms accounted for (81) 96 percent of 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 export share of integrated plants under the pure-assembly regime.

Helpman *et al.* (2004) show that a conceptually valid measure of productivity dispersion is the standard deviation of the log of firm sales across firms within an industry. We use the standard deviation of (log) sales across all firms within an industry in the U.S. (σ_j^{θ}) as the empirical counterpart of productivity dispersion, and estimate the following equation to examine Hypothesis 2:

$$\frac{X_{jc}^{IV}}{X_{jc}^{IV}+X_{jc}^{IO}} = d_c + \gamma_H ln\left(\frac{H_j}{L_j}\right) + \gamma_E ln\left(\frac{E_j}{L_j}\right) + \gamma_P ln\left(\frac{P_j}{L_j}\right) + \gamma_M ln\left(\frac{M_j}{L_j}\right) + \delta_\theta \sigma_j^\theta + \delta_{\theta\eta} \sigma_j^\theta \eta_j + \varepsilon_{jc} \quad (8)$$

where $\ln(E_j/L_j)$ and $\ln(P_j/L_j)$ are the measures of equipment-capital and plant-capital intensity and η_j is a measure of one of the intensity proxies for headquarter inputs: skill or equipment-capital. We control for importer heterogeneity by including 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 product-country sample, we report the estimates of equation (8) in Table 7. We include all stand-alone headquarter intensity measures as controls. We cluster the standard errors at the SIC 4-digit level. Columns (1) and (2) report results for the import-and-assembly regime, while columns (3) and (4) report those for pure-assembly. For import-and-assembly, we do not find evidence supporting a positive relationship between sectoral productivity dispersion and the share of integrated plants' exports. While the coefficient on the stand-alone dispersion term is positive and statistically significant when equipment-capital intensity is used for η_j, the coefficient on the interaction term is negative and statistically significant in column (2). When skill intensity is used as a measure of headquarter intensity, the coefficients are no longer significant.

For pure-assembly, when skill intensity is interacted with σ_j^{θ}, the estimated coefficients on both the dispersion and the interaction terms are positive and statistically significant. When we use equipment-capital intensity to proxy for η_j, we continue to find a strongly positive coefficient on the interaction term, but the stand-alone dispersion term is not statistically significant. When we restrict the sample to consider only exports to the US, the results reported in columns (7) and (8) show that all coefficients on both the dispersion and the interaction term are positive and statistically significant (at the 1% level). In sum, the relationship between productivity dispersion and the export share of integrated plants is higher in sectors with higher headquarter intensity, supporting Hypothesis 2 regarding the pure-assembly regime.

The empirical specification above imposes a linear restriction on the relationship between productivity dispersion and the prevalence of integration. To examine the theoretical prediction in a more flexible framework, and to identify the cut-off level of headquarter intensity over which productivity dispersion matters, we follow Nunn and Trefler (2008) and consider a regression that allows the relationship between firm heterogeneity and integrated plants' exports to differ by quintiles of headquarter intensity. We rank our SIC-1987 4-digit industries by headquarter intensity measured either by skill or by capital-equipment. Then we divide the industries into 5 quintiles of headquarter intensity. We define headquarter intensity quintile dummies as $I_{jp}^{\eta} = 1$ 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. The coefficients of interest are the $\delta_{\theta\eta p}$'s.

$$\frac{X_{jc}^{IV}}{X_{jc}^{IV}+X_{jc}^{IO}} = d_c + \gamma_H ln\left(\frac{H_j}{L_j}\right) + \gamma_E ln\left(\frac{E_j}{L_j}\right) + \gamma_P ln\left(\frac{P_j}{L_j}\right) + \gamma_M ln\left(\frac{M_j}{L_j}\right) + \sum_{p=1}^{5} \delta_{\eta p} I_{jp}^{\eta} + \sum_{p=1}^{5} \delta_{\theta\eta p} (\sigma_j^{\theta} * I_{jp}^{\eta}) + \varepsilon_{jc} \quad (9)$$

The results are reported in Table 8. Columns (1) through (4) report results for the import-and-assembly regime, while columns (5) through (8) report those for pure-assembly. The average effect across all industries is positive and statistically significant for the pure-assembly regime and is estimated at 0.09 or 0.07 depending on whether we include quintile dummies or not (columns (5) and (6)). This suggests that a one-standard deviation increase in productivity dispersion is associated with an increase in the export share of integrated plants of about 2 percentage points. The coefficient is not statistically significant for the import-and-assembly sample (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 (7) and (8)) show a jump in the magnitude of the positive relationship at around the 4th quintile. Specifically, the coefficient on the interaction between the quantile dummies and the productivity dispersion measure becomes positive and statistically significant after the 4th quintile for both measures of headquarters intensity, skill and capital-equipment. This means that for the highest headquarter-intensive industries, an increase in productivity dispersion increases the share of integrated plants' exports. There appears to be a cut-off level of headquarter intensity above which productivity dispersion increases the share of integrated firms exports; for industries below this cut-off, there is no significant relationship. Regarding exports under import-and-assembly, we find no significant relationship between productivity dispersion and the export share of integrated plants, as suggested by the model (see columns (3) and (4)).

As further robustness checks, we also use a Chinese-based measure of productivity dispersion. Our measure of productivity dispersion is the standard deviation of the log of export revenue of export-processing plants in each sector. The results using these measures are reported in Table 9. Under import-and-assembly (columns (1) and (2)), the coefficients on the interaction terms are insignificant, while under pure-assembly, we continue to obtain positive and significant coefficients on the interaction terms, supporting the results using the US-based productivity dispersion measures and Hypothesis 2.

5.3 Examining the Effects of the Contractibility of Suppliers' Inputs

Antràs and Helpman (2008) relax the assumption that relationship-specific investments are completely non-contractible, and allow for varying degrees of contractibility across inputs and countries. An important prediction is that the degree of which the investments 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 to integrate. Therefore, in this section, we investigate the following hypothesis:

Hypothesis 3: Contractibility of Investments and FDI

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”). Thus, the motives for integration 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 (“Surprise Effect”). As such, integration becomes preferred even in sectors with a lower headquarter intensity.

(1) In headquarter-intensive sectors, if the “Standard Effect” dominates, the export share of integrated plants' exports decreases under import-and-assembly.
(2) If the “Surprise Effect” dominates, the export share of integrated plants' exports increases under import-and-assembly.
(3) The relationship is ambiguous for pure-assembly, and is absent in assembly-intensive sectors.

To examine Hypothesis 3, we estimate the following equation:

$$\frac{X_{jc}^{IV}}{X_{jc}^{IV}+X_{jc}^{IO}} = d_c + \gamma_H ln\left(\frac{H_j}{L_j}\right) + \gamma_E ln\left(\frac{E_j}{L_j}\right) + \gamma_P ln\left(\frac{P_j}{L_j}\right) + \gamma_M ln\left(\frac{M_j}{L_j}\right) + \delta_Z Z_j + \delta_{Z\eta} Z_j \eta_j + \varepsilon_{jc} \quad (10)$$

where Z_j stands for the contractibility of the assembly plant's inputs.[17] 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 $\delta_{Z\eta}$ can be positive or negative for either the pure-assembly or import-and-assembly regime, depending on whether the "Standard Effect" dominates the "Surprise Effect" or vice versa.

Table 10 reports estimates of equation (10) for a sample of unilateral exports to each country and for a sample of exports to the US only, both at the HS 6-digit level. Headquarter intensity measures are always controlled for. For pure-assembly exports, we find no evidence of a significant relationship between contract completeness and the prevalence of integration. This is expected for the same reason that headquarter intensity has an indeterminate impact on the prevalence of integration in this regime. For import-and-assembly exports, when capital-equipment intensity is used to measure headquarter inputs, 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 export share of integrated plants in the more headquarter-intensive sectors. This result suggests the dominance of the "Standard Effect". The results obtained are the same whether we consider the full sample or the sample of exports to the US only.

To identify the cut-off level of headquarter intensity over which contract completeness of inputs affects the propensity to integrate, we follow Nunn and Trefler (2008a) and consider a regression that allows the relationship between the contractibility of suppliers' inputs and integrated plants' 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. Country fixed effects, headquarter intensity quintile dummies and headquarter intensity controls are included. The standard errors are clustered at the industry level. The coefficients of interest are the $\delta_{Z\eta p}$'s.

$$\frac{X_{jc}^{IV}}{X_{jc}^{IV}+X_{jc}^{IO}} = d_c + \gamma_H ln\left(\frac{H_j}{L_j}\right) + \gamma_E ln\left(\frac{E_j}{L_j}\right) + \gamma_P ln\left(\frac{P_j}{L_j}\right) + \gamma_M ln\left(\frac{M_j}{L_j}\right) + \sum_{p=1}^{5} \delta_{\eta p} I_{jp}^{\eta} + \sum_{p=1}^{5} \delta_{Z\eta p} (Z_j * I_{jp}^{\eta}) + \varepsilon_{jc} \quad (11)$$

[17] Specifically, Nunn (2007) uses the input-output table for the U.S. industries to gauge the extent of the overall market thickness of the upstream sectors of an industry.

The results are reported in Table 11. For import-and-assembly (columns (1) and (2)), we find a negative impact on integrated exports from the interaction between input contractibility and headquarter intensity for the top 40% of headquarter-intensive sectors. In particular, the coefficients on the interaction between the 4th and 5th quintile dummies and the contractibility measure are negative and statistically significant when equipment-capital intensity is used as a proxy for headquarter intensity. For pure-assembly (columns (3) and (4)), no significant relationship is found. These results confirm the finding reported above that an increased contractibility of the supplier's inputs reduces the export share of integrated plants in the more headquarter-intensive sectors under import-and-assembly.

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, which let us observe the allocation of ownership and control rights over imported inputs between a foreign client and a domestic plant. 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. To examine how choices of organizational structure are affected by the consideration of allocation arrangements of control rights and ownership over components in export processing, we present an extension of the Antràs and Helpman (2004) model to consider component search for assembling. By considering two ownership structures under two trade regimes, our model predicts that headquarter intensity and the prevalence of integration are positively correlated under import-and-assembly. The relationship is ambiguous under pure-assembly.

Our empirical results show that when Chinese plants import materials from abroad and assemble them, the export share of integrated plants 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 no relationship between the prevalence of vertical integration and the intensity of headquarter inputs or the degree of contract incompleteness of inputs. These results are consistent with the model, and are relevant for the situation when ownership of the plant's asset and imported inputs are to be considered jointly.

Consistent with the sorting of firms into different production modes based on productivity, we find that an increased productivity dispersion is associated with a bigger export share of integrated plants under pure-assembly, but not under import-and-assembly. In particular, in sectors with higher headquarter intensity, the share of integrated plants' exports increases with firm productivity dispersion. Our 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.

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Table 1. Export Shares Across 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 2. Export Shares of the 4 Ownership x Trade Production 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 3. Headquarter Intensity and the Export Share of Vertically Integrated Plants (HS6 Level)

Trade Regime:	Import-and-assembly				Pure-assembly			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill Intensity, ln(H/L)	0.121***		0.137***		-0.066		-0.081*	
	(2.998)		(3.238)		(-1.533)		(-1.892)	
Capital Intensity, ln(K/L)	-0.104**	-0.142***			-0.026	0.002		
	(-2.237)	(-3.719)			(-0.804)	(0.064)		
R&D Intensity, ln(RD/Q)		0.069*		0.060		-0.070**		-0.069**
		(1.954)		(1.636)		(-2.169)		(-2.075)
Material Intensity, ln(M/L)			-0.085*	-0.073			0.024	0.002
			(-1.721)	(-1.433)			(0.585)	(0.055)
Equipment Intensity, ln(E/L)			0.068	-0.004			-0.117*	-0.046
			(1.108)	(-0.065)			(-1.961)	(-0.727)
Plant Intensity, ln(P/L)			-0.123**	-0.100*			0.072	0.048
			(-2.470)	(-1.908)			(1.114)	(0.706)
N	3496	3376	3496	3376	2769	2660	2769	2660
No. clusters	348	317	348	317	331	300	331	300
R^2	0.032	0.024	0.041	0.029	0.004	0.005	0.008	0.006

Dependent Variable: China's foreign-affiliated plants' 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 4. Headquarter Intensity and the Export Share of Vertically Integrated Plants (HS6-Country Level)

Trade Regime:	Import-and-assembly				Pure-assembly			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill Intensity, ln(H/L)	0.168***		0.191***		-0.090**		-0.119***	
	(4.914)		(5.310)		(-2.390)		(-3.367)	
Capital Intensity, ln(K/L)	-0.086**	-0.138***			0.031	0.071		
	(-2.048)	(-3.902)			(0.736)	(1.613)		
R&D Intensity, ln(RD/Q)		0.101***		0.096***		-0.095***		-0.088***
		(2.907)		(2.656)		(-2.825)		(-2.665)
Material Intensity, ln(M/L)			-0.093**	-0.076			-0.009	-0.020
			(-2.357)	(-1.588)			(-0.204)	(-0.463)
Equipment Intensity, ln(E/L)			0.081**	-0.030			-0.116**	-0.038
			(1.989)	(-0.657)			(-2.340)	(-0.648)
Plant Intensity, ln(P/L)			-0.118***	-0.071*			0.161***	0.129***
			(-3.076)	(-1.726)			(3.546)	(2.605)
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
N	72429	69669	72429	69669	34877	32883	34877	32883
No. clusters	348	317	348	317	331	300	331	300
R^2	0.065	0.051	0.076	0.055	0.081	0.084	0.095	0.090

Dependent Variable: China's foreign-affiliated plants' 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 5. Headquarter Intensity and the Export Share of Vertically Integrated Plants (Different Country Groups) (HS6 Level)

	Import-and-assembly					
	(1)	(2)	(3)	(4)	(5)	(6)
Country Group:	LIC	HIC	US	Japan	Europe HIC	Exclude HK
Skill Intensity, ln(H/L)	0.222***	0.125***	0.144***	0.165***	0.155***	0.157***
	(5.480)	(2.941)	(3.547)	(4.419)	(3.184)	(3.267)
Material Intensity, ln(M/L)	-0.099*	-0.086*	-0.109**	-0.079*	-0.085*	-0.085
	(-1.936)	(-1.750)	(-2.247)	(-1.755)	(-1.687)	(-1.593)
Equipment Intensity, ln(E/L)	0.185**	0.056	0.115**	0.140***	0.067	0.103*
	(2.448)	(0.929)	(2.055)	(2.877)	(1.098)	(1.726)
Plant Intensity, ln(P/L)	-0.174***	-0.112**	-0.156***	-0.182***	-0.147***	-0.163***
	(-2.652)	(-2.298)	(-3.135)	(-4.382)	(-2.823)	(-3.084)
N	1368	3412	2314	2494	2413	3362
No. Clusters	273	344	315	326	318	346
No. Countries	47	59	1	1	38	233
R^2	0.059	0.037	0.047	0.047	0.052	0.050
	Pure-assembly					
	(1)	(2)	(3)	(4)	(5)	(6)
Country Group:	LIC	HIC	US	Japan	Europe HIC	Exclude HK
Skill Intensity, ln(H/L)	-0.085	-0.083*	-0.099**	-0.175***	-0.122***	-0.117***
	(-1.328)	(-1.891)	(-2.313)	(-4.620)	(-2.781)	(-2.997)
Material Intensity, ln(M/L)	-0.031	0.030	0.036	0.048	0.029	0.023
	(-0.419)	(0.696)	(0.693)	(1.155)	(0.519)	(0.536)
Equipment Intensity, ln(E/L)	0.210**	-0.139**	-0.182***	-0.160**	-0.086	-0.074
	(2.418)	(-2.339)	(-3.110)	(-2.574)	(-1.407)	(-1.300)
Plant Intensity, ln(P/L)	-0.001	0.079	0.175***	0.087	0.147*	0.063
	(-0.008)	(1.223)	(2.689)	(1.441)	(1.864)	(1.001)
N	548	2708	1599	1755	1536	2495
No. Clusters	181	330	289	290	277	323
No. Countries	47	59	1	1	38	233
R^2	0.058	0.010	0.025	0.033	0.026	0.014

Dependent Variable: China's foreign-affiliated plants' exports as a share of total exports. 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 6. Headquarter Intensity and the Export Share of Vertically Integrated Plants (Using Chinese Data to Measure Factor Intensities)

Trade Regime	Import-and-assembly				Pure-assembly			
Observation unit	HS6 Level		HS6-Country Level		HS6 Level		HS6-Country Level	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity	0.088**		0.106***		-0.096***		-0.101**	
	(2.359)		(3.385)		(-2.639)		(-2.251)	
Capital Intensity	-0.184***	-0.132***	-0.142***	-0.083**	0.013	-0.045	-0.017	-0.080*
	(-5.198)	(-3.907)	(-3.697)	(-2.151)	(0.315)	(-1.217)	(-0.293)	(-1.708)
RD+Advert intensity		0.112***		0.102***		-0.057		-0.079*
		(3.517)		(3.628)		(-1.538)		(-1.771)
Country FE	no	no	yes	yes	no	no	yes	yes
N	3504	3111	72478	63733	2773	2467	34893	31282
No. Clusters	350	314	350	314	333	300	333	300
R^2	0.029	0.031	0.047	0.043	0.008	0.005	0.082	0.083

Dependent Variable: China's foreign-affiliated plants' exports as a share of total exports under each trade regime. An observation is a 6-digit HS product category. 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. RD+Advert intensity is measured by the log ratio of the sum of R & D and advertisement expenditure to value-added. 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. Productivity Dispersion and the Export Share of Vertically Integrated Plants (US-Export-based Dispersion Measure) (HS6-Country Level)

	Exports to Each Country				Exports to the USA			
	Import-and-assembly		Pure-assembly		Import-and-assembly		Pure-assembly	
Headquarter intensity measure:	skill	equipment	skill	equipment	skill	equipment	skill	equipment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dispersion	0.050	0.071***	0.270***	0.033	0.029	0.081***	0.471***	0.067**
	(0.921)	(3.049)	(2.946)	(1.367)	(0.435)	(2.717)	(3.929)	(2.060)
Dispersion interaction	0.063	-0.336***	0.409**	0.547***	0.045	-0.499***	0.757***	0.483***
	(0.486)	(-2.909)	(2.291)	(3.529)	(0.322)	(-4.014)	(3.341)	(2.628)
Country fixed effects	yes	yes	yes	yes	no	no	no	no
Headquarter intensity controls	yes	yes	yes	yes	yes	yes	yes	yes
N	72365	72365	34867	34867	2314	2314	1598	1598
No. clusters	346	346	329	329	315	315	288	288
R^2	0.076	0.079	0.100	0.110	0.047	0.054	0.048	0.043

Dependent Variable: China's foreign-affiliated plants' 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. 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 8. Productivity Dispersion and the Export Share of Vertically Integrated Plants (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)
Headquarter intensity measure:			skill	equipment			skill	equipment
Dispersion	0.023	0.022			0.087***	0.073***		
	(1.265)	(1.226)			(2.985)	(2.950)		
Dispersion interacted with:								
Ii1			0.008	0.191***			0.163	0.007
			(0.072)	(2.911)			(1.299)	(0.088)
Ii2			0.118	0.108			0.003	0.013
			(1.126)	(1.192)			(0.032)	(0.146)
Ii3			0.088	0.074			-0.093	0.336
			(0.759)	(0.589)			(-0.658)	(1.576)
Ii4			-0.037	0.163			0.184*	0.430***
			(-0.265)	(1.478)			(1.712)	(2.821)
Ii5			0.067	-0.122			0.575***	0.410***
			(0.763)	(-1.148)			(3.181)	(3.512)
Country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Quintile fixed effects	no	yes	yes	yes	no	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes	yes	yes	yes	yes
N	72365	72365	72365	72365	34867	34867	34867	34867
No. Clusters	346	346	346	346	329	329	329	329
R^2	0.076	0.085	0.079	0.085	0.032	0.120	0.110	0.120

Dependent Variable: China's foreign-affiliated plants' exports as a share of total exports under each trade regime. An observation is a 6-digit HS product category to each country. 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 9. Productivity Dispersion and the Export Share of Vertically Integrated Plants (Chinese Firms-export-based Dispersion Measure) (HS6-Country level)

	Exports to Each Country			
	Import-and-assembly		Pure-assembly	
Headquarter intensity measure:	skill	equipment	skill	equipment
	(1)	(2)	(3)	(4)
Dispersion	0.107*	0.201***	0.254***	-0.095***
	(1.681)	(6.778)	(2.980)	(-3.065)
Dispersion interaction	-0.169	0.036	0.488***	0.306**
	(-1.660)	(0.416)	(4.013)	(2.029)
Country fixed effects	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes
N	72051	72051	34663	34663
No. clusters	340	340	327	327
R^2	0.120	0.110	0.110	0.100

Dependent Variable: China's foreign-affiliated plants' 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. 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 10. Contractual Completeness and the Export Share of Vertically Integrated Plants (HS6-Country Level)

	Exports to Each Country				Exports to the USA			
	Import-and-assembly		Pure-assembly		Import-and-assembly		Pure-assembly	
Headquarter intensity measure:	skill	equipment	skill	equipment	skill	equipment	skill	equipment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Contractibility	-0.062	0.044	-0.056	-0.023	-0.042	0.030	-0.156	0.020
	(-0.561)	(1.053)	(-0.410)	(-0.416)	(-0.355)	(0.612)	(-1.050)	(0.370)
Contractibility interaction	0.009	-0.298***	-0.146	0.191	0.047	-0.301***	-0.303	0.100
	(0.068)	(-3.167)	(-0.731)	(1.405)	(0.311)	(-2.600)	(-1.491)	(0.783)
Country fixed effects	yes	yes	yes	yes	no	no	no	no
Headquarter intensity controls	yes	yes	yes	yes	yes	yes	yes	yes
N	58967	58967	26416	26416	1858	1858	1232	1232
No. clusters	279	279	263	263	251	251	226	226
r2	0.081	0.088	0.088	0.090	0.050	0.057	0.014	0.010

Dependent Variable: China's foreign-affiliated plants' 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. 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. Contractual Completeness and the Export Share of Vertically Integrated Plants (Exports to Each Country, Interaction with Different Headquarter-intensity Quintiles) (HS6-Country Level)

	Import-and-assembly		Pure-assembly	
Headquarter intensity measure:	skill	equipment	skill	equipment
	(1)	(2)	(3)	(4)
Contractibility interacted with:				
Ii1	-0.147*	-0.001	0.214*	-0.018
	(-1.968)	(-0.013)	(1.899)	(-0.290)
Ii2	-0.043	0.138***	-0.024	-0.043
	(-0.704)	(2.862)	(-0.373)	(-0.828)
Ii3	0.077	-0.038	-0.070	0.139*
	(1.514)	(-0.760)	(-0.905)	(1.828)
Ii4	-0.087	-0.132**	0.094	-0.003
	(-0.921)	(-2.040)	(1.333)	(-0.052)
Ii5	-0.075	-0.230***	0.098	-0.071
	(-1.378)	(-2.843)	(1.015)	(-0.588)
Country fixed effects	yes	yes	yes	yes
Quintile fixed effects	yes	yes	yes	yes
Headquarter intensity controls	yes	yes	yes	yes
N	58967	58967	26416	26416
No. Clusters	279	279	263	263
R^2	0.088	0.095	0.100	0.110

Dependent Variable: China's foreign-affiliated plants' 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. 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 A1. Summary Statistics of the Export Share of Vertically Integrated Plants Across HS6 Categories

Trade regime	10th	25th	50th	75th	90th	mean	#Obs.
Import-and-assembly	0	0.598	0.923	1	1	0.746	3627
Pure-assembly	0	0	0.264	0.797	1	0.392	2880

Table A2. Summary Statistics of Headquarter Intensity Measures (Across SIC 4-Digit)

	10th	25th	50th	75th	90th	mean	#Obs.
Skill Intensity	-1.330	-1.165	-0.973	-0.757	-0.557	-0.966	451
Capital Intensity	0.224	0.564	0.920	1.330	1.852	0.976	452
Equipment Intensity	-0.374	-0.015	0.425	0.910	1.465	0.487	453
Structure Intensity	-0.717	-0.471	-0.128	0.339	0.789	-0.034	454
Material Intensity	0.378	0.665	1.025	1.423	1.904	1.092	455
R&D Intensity	-6.269	-5.331	-4.474	-3.677	-3.012	-4.585	414
Contractibility	0.209	0.307	0.507	0.712	0.828	0.513	361
ln(college emp/emp) Chinese plants	-3.069	-2.669	-2.273	-1.819	-1.437	-2.250	513
ln(high-sch emp/emp) Chinese plants	-1.179	-1.031	-0.797	-0.618	-0.418	-0.811	513
ln(real value K/real Y) Chinese plants	-1.336	-1.082	-0.814	-0.563	-0.086	-0.768	523
R&D + Advert. Intensity Chinese plants	-7.051	-6.575	-5.949	-5.246	-4.493	-5.857	458

Figure 1. An Assembly-intensive Sector when $\psi_{NO} \geq \psi_{SO}$

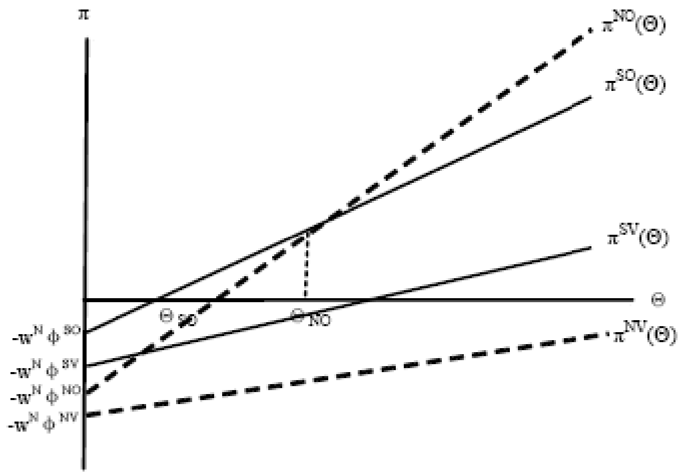
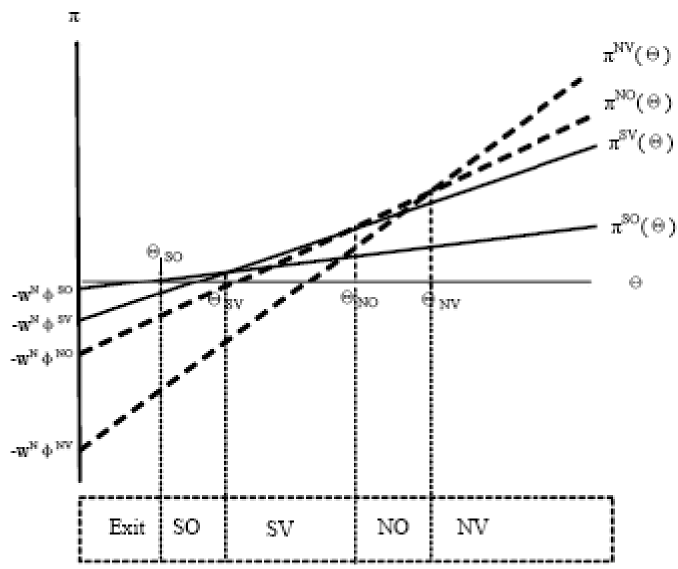


Figure 2. A Headquarter-intensive Sector



Appendix

Deriving Firm Profits under Pure-Assembly

Under pure-assembly, H invests in both component search and headquarter services. The cost of component search is λ^N, while wages in the North and South are w^N and w^S, respectively. 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 gives the profit-maximization investment levels a^*, h^* and m^* in terms of w^S, w^N, λ, θ, D, η's and importantly, β_{Nk}.[18]

Plugging the privately optimal investment levels into the joint profit function, 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

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

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

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

where $\omega(\eta^h) = 1 - \overline{\eta}^m - \eta^h$. Notice $\beta_N^{*'}(\eta^h) > 0$, which is an essential property for determining the ex-ante optimal choice of production mode.

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

Deriving Firm Profits under Import-and-Assembly

Under import-and-assembly, H invests only in headquarter activities. The cost of component search is λ^N, while wages in the North and South are w^N and w^S, respectively. 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 gives the profit-maximization investment levels a^*, h^* and m^* in terms of w^S, w^N, λ, θ, D, η's and importantly, β_{Sk}.[19]

Plugging the privately optimal investment levels into the joint profit function, we obtain firm operating profit 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

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

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

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

Notice that $\beta_S^{*'}(\eta^h) > 0$, which is an essential property for determining the ex-ante optimal choice of production mode.

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

The Analysis on the Conditions for $\boldsymbol{\psi_{Nk} > \psi_{Sk}}$

To examine when $\psi_{Nk} > \psi_{Sk}$ for a given organization mode k, let us focus on a constant component intensity η^m for simplicity. $\psi_{Nk} > \psi_{Sk}$ if the following inequality holds:[20]

$$\left(\frac{\lambda^N}{\lambda^S}\right)^{\eta^m} \leq \frac{\varphi(\beta_{Nk},\eta^h)}{\zeta(\beta_{Sk},\eta^h)} \tag{12}$$

where $\varphi(\xi,\eta^h) = \left[1-\alpha\left(\xi\eta^h+\xi\eta^m+(1-\xi)(1-\eta^h-\eta^m)\right)\right]^{\frac{1-\alpha}{\alpha}}\xi^{\eta^h+\eta^m}(1-\xi)^{1-\eta^h-\eta^m}$ and $\zeta(\xi,\eta^h) = \left[1-\alpha\left(\xi\eta^h+(1-\xi)(1-\eta^h)\right)\right]^{\frac{1-\alpha}{\alpha}}(1-\xi)^{1-\eta^h}\xi^{\eta^h}$. 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).[21] 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 (12) to hold. For instance, if control rights over components greatly enhance A's outside option (i.e., high γ), β_{NO} can be much bigger than β_{SO}. Importantly, in sufficiently headquarter-intensive sectors (i.e., η^h is sufficiently large), both φ and ζ are increasing in ξ and $\varphi > \zeta$ except when ξ is very small.

Deriving Expressions of the Market Share of Integrated Firms Under Each Trade Regime

Recall that for a headquarter-intensive sector, total export value when all four production modes exist is

$$\begin{aligned} X &= D\int_{\Theta_{SO}}^{\infty} R(\Theta)dG(\Theta) \\ &= D[\psi_{SO}V(\Theta_{SO},\Theta_{SV})+\psi_{SV}V(\Theta_{SV},\Theta_{NO})+\psi_{NO}V(\Theta_{NO},\Theta_{NV})+\psi_{NV}V(\Theta_{NV},\infty)] \end{aligned}$$

where

$$V(A,B) = \int_A^B \Theta dG(\Theta) = \Gamma(A^{1-\kappa}-B^{1-\kappa})$$

where $\Gamma = \frac{\kappa\Theta_{\min}^{\kappa}}{\kappa-1}$.

The productivity cutoffs (production mode margins) can be solved using a set of indifference conditions (e.g. $\pi_{SV}(\Theta_{NO},D,\eta^a,\eta^h) = \pi_{NO}(\Theta_{NO},D,\eta^a,\eta^h)$) as

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

21 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.

$$\Theta_{SO} = \frac{B\phi_{SO}}{\psi_{SO}}$$

$$\Theta_{SV} = \frac{B(\phi_{SV} - \phi_{SO})}{\psi_{SV} - \psi_{SO}}$$

$$\Theta_{NO} = \frac{B(\phi_{NO} - \phi_{SV})}{\psi_{NO} - \psi_{SV}}$$

$$\Theta_{NV} = \frac{B(\phi_{NV} - \phi_{NO})}{\psi_{NV} - \psi_{NO}}$$

where $B = w_N/D$.

Export value of each production mode can be expressed in terms of the productivity cutoffs as:

$$X_{SO} = D\Gamma\psi_{SO}(\Theta_{SO}^{1-\kappa} - \Theta_{SV}^{1-\kappa}); \quad X_{SV} = D\Gamma\psi_{SV}(\Theta_{SV}^{1-\kappa} - \Theta_{NO}^{1-\kappa}) \tag{13}$$
$$X_{NO} = D\Gamma\psi_{NO}(\Theta_{NO}^{1-\kappa} - \Theta_{NV}^{1-\kappa}); \quad X_{NV} = D\Gamma\psi_{NV}\Theta_{NV}^{1-\kappa}$$

We can express the market share of integrated plants exports under import-and-assembly as

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

The market share of integrated plants exports under pure-assembly is

$$\frac{X_{NV}}{X_{NV} + X_{NO}} = \left(1 + \frac{X_{NO}}{X_{NV}}\right)^{-1}$$
$$= \left[1 + \frac{\psi_{NO}}{\psi_{NV}}\left(\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{1-\kappa} - 1\right)\right]^{-1}$$

Proof of Hypothesis 1

The market share of integrated plants' exports under import-and-assembly is given in (4). In sufficiently headquarter-intensive sectors, all four production modes exist and that $\psi_{lV}/\psi_{lO} > 1$ and is increasing in η^h for $l \in \{N,S\}$ (see Antràs, 2003). Similarly, with the assumption that $\beta_{NO} > \beta_{SV}$, $\psi_{NO}/\psi_{SV} > 1$ and is increasing in η^h for $l \in \{N,S\}$. It follows that $\frac{d}{d\eta^h}\left(\frac{\Theta_{NO}}{\Theta_{SO}}\right) > 0$, $\frac{d}{d\eta^h}\left(\frac{\Theta_{NO}}{\Theta_{SV}}\right) \lesseqgtr 0$, $\frac{d}{d\eta^h}\left(\frac{\Theta_{SV}}{\Theta_{SO}}\right) < 0$, $\frac{d}{d\eta^h}\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right) \lesseqgtr 0$. Using these comparative statics, it is straightforward to show that $\frac{X_{SV}}{X_{SO}+X_{SV}}$ in (4) is increasing in η^h.

The market share of integrated plants exports under pure-assembly is given in (5). Since the sign of $\frac{d}{d\eta^h}\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)$ is ambiguous, the market share of integrated assembly plants under pure-assembly is ambiguous. To understand what factors may drive the export share of integrated plants to increase, consider $\frac{d}{d\eta^h}\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)$, that is the key determinant of the sign of the relationship between this share and headquarter intensity across sectors. We find that $sgn\left(\frac{d}{d\eta^h}\frac{\Theta_{NO}}{\Theta_{NV}}\right)$ is positive if $\left|\frac{\frac{d}{d\eta^h}(\psi_{NV}/\psi_{NO})}{\frac{d}{d\eta^h}(\psi_{SV}/\psi_{NO})}\right| > \frac{\psi_{NV}/\psi_{NO}-1}{1-\psi_{SV}/\psi_{NO}}$, and negative otherwise. This inequality is more likely to hold if the efficiency gains (due to changes in the incentives to invest) by obtaining ownership of the plant's asset is greater than the loss of giving up control rights over imported materials.

Proof of Hypothesis 2

Let us denote the variance of Θ by $V = \kappa\Theta^2_{\min}(\kappa-1)^{-2}(\kappa-2)^{-1}$. It can be shown that $\frac{dV}{d\kappa} < 0$.

Using (4), and that $\Theta_{SV}/\Theta_{SO} > 1$ and $\Theta_{NO}/\Theta_{SO} > 1$, the sign of $\frac{d}{d\kappa}\left(\frac{X_{SV}}{X_{SO}+X_{SV}}\right)$ is indeterminate.

Using (5), and that $\Theta_{NV}/\Theta_{NO} > 1$, it can be shown that $\frac{d}{d\kappa}\left(\frac{X_{NV}}{X_{NV}+X_{NO}}\right) < 0$ (i.e., $\frac{X_{NV}}{X_{NV}+X_{NO}}$ is increasing with the variance of Θ).