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Determinants of vertical integration in export processing: Theory and evidence from China ☆

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ABSTRACT

This paper examines the determinants of vertical integration versus outsourcing in export processing, by exploiting the coexistence of two export processing regimes in China, which designate by law who owns and controls the imported components. Based on a variant of the Antràs-Helpman (2004) model, we show theoretically that control over imported components for assembly can affect firm integration decisions. Our empirical results show that when Chinese plants control the use of components, the export share of foreign-owned plants is positively correlated with the intensity of inputs provided by the headquarter (capital, skill, and R&D). These results are consistent with the property-rights theory of intra-firm trade. However, when foreign firms own and control the components, there is no evidence of a positive relationship between the intensity of headquarters' inputs and the prevalence of vertical integration. The results are consistent with our model that considers control over imported components as an alternative to asset ownership to alleviate hold-up by export-processing plants.

1. Introduction

Export processing, in which a final-good producer offshores the final stage of production to an assembly plant in a foreign country, has been an important part of developing nations' economies. It employed over 63 million people in the developing world,[1] and accounted for over half of total exports in countries such as China and Mexico in recent years (Bergin et al., 2009). Recent studies have shown how export processing and offshoring in general have important macroeconomic impacts on the host countries.[2] In export processing, final-good producers are often confronted with the decisions of whether to outsource to or integrate with the foreign assembly plant, which in turn affect the macroeconomic effects of offshoring. This paper studies the prevalence of vertical integration versus outsourcing in export processing using detailed product-level trade data from China's Customs.

We exploit the special regulatory regimes governing processing trade in China. These legal arrangements designate by law which party of a global production relationship has control rights over the imported materials, which are critical for export processing. Specifically, export processing in China has been governed under two regimes since the early 1980s, which are referred to as pure-assembly and import-assembly.[3] The main difference between the two regimes lies in the allocation of control rights of the imported inputs. In the

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[1] See International Labour Organization (2007).

[2] For instance, Bergin et al. (2009, 2011) link offshoring activities to higher employment volatility in Mexico; and Sheng and Yang (2011) study how exporting processing activities contribute to increasing returns to skills in China after its accession to the WTO.

[3] See Feenstra and Hanson (2005) for a detailed description of these two trade regimes in China.

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pure-assembly regime, a foreign firm supplies components to a Chinese assembly plant and retains ownership and control over the imported inputs throughout the production process. In the import-assembly regime, a Chinese assembly plant imports components of its own accord and retains control over their use. Based on a variant of the Antràs-Helpman (2004) model that incorporates component-purchase investments, we provide empirical evidence on how control over imported inputs may serve as an alternative to asset ownership to mitigate hold-up by foreign suppliers, which in turn shape the organizational choices of multinational production.[4]

While there is an extensive theoretical literature on the pattern of intra-firm trade, empirical evidence is relatively scant and exclusively focuses on the developed world.[5] This paper thus complements the existing literature by providing evidence on the make-or-buy decisions in processing trade in a developing country. In particular, our results empirically examine existing theory on the relationship between industry characteristics and the relative prevalence of vertical integration versus outsourcing (Antràs, 2003; Antràs and Helpman, 2004, 2008). Since this literature so far abstracted from the discussion of control rights of imported components, which are particularly important for processing trade in developing countries, we extend the Antràs-Helpman (2004) model to capture the policy features in China. In the model, the final-good producer in the North invests in headquarter services (e.g. marketing), while the assembly plant in the South invests in assembly activities. Who invests in global component purchase depends on the trade regime. In particular, the final-good producer invests in component purchases under pure-assembly, whereas the assembly plant invests in component purchases under import-assembly.

Our model, which features firm heterogeneity, predicts that vertical integration and outsourcing in both import-assembly and pure-assembly regimes can coexist in sectors where headquarter investments are important. In particular, our model predicts that the most productive final-good producers in the North choose to integrate with the assembly plant and own the imported materials when offshoring assembly tasks to the South, whereas the least productive final-good producers allocate both the ownership of the plant's asset and the control rights over imported materials to the assembly plant. Based on this ranking of production modes, the model yields a positive correlation between the export share of integrated firms that operate under import-assembly and headquarter intensity across sectors, consistent with the main prediction by Antràs (2003). The cross-sector relationship between headquarter intensity and the prevalence of integration under pure-assembly is ambiguous. The reason for the ambiguity is that in a headquarter-intensive sector where safeguarding the headquarter's investment incentives is important, a foreign client can choose to either own and control imported inputs or own the plant's assets to alleviate hold-up. The export volume from integrated plants increases for both import-assembly and pure-assembly when the headquarter intensity of the sector rises. If the incremental gain from integration is sufficiently smaller with input control than without, the export volume can increase more for the former than the latter, resulting in a lower share of integrated plants under pure-assembly in total processing trade.

We investigate empirically the implications of introducing controls over input purchases on the prevalence of different global production modes in processing trade. To this end, we use detailed firm- and product-level trade data collected by the Customs General Administration of China for 2005. We find a positive and significant relationship between the share of integrated plants' exports from the import-assembly regime and various measures of the intensity of headquarter inputs (i.e., skill, R&D, and physical capital intensities). The results are robust when we restrict the sample to include only Chinese exports to the US and to different country groups based on income levels, as well as when country fixed effects are controlled for. In sum, we find evidence supporting our predictions and the property-rights theory of intra-firm trade.

However, we find no evidence of a positive relationship between the degree of headquarter intensity and integrated plants' exports from the pure-assembly regime, where the foreign firm retains ownership and control rights over the imported inputs. These results provide indirect support to our theoretical prediction that control over the use of imported components serves as an alternative to asset ownership to mitigate hold-up by foreign assembly plants. It is worth noting that this result should not be taken as a rejection of the existing theory on intra-firm trade, but rather as a confirmation of its predictions in a more complex setting.

Our paper relates to several strands of studies. First, our work is most related to and to a large extent inspired by Feenstra and Hanson (2005), who are the first to exploit the special regulatory arrangements for processing trade in China to examine empirically the prevalence of integration in processing trade. Similar to their work, we also adopt the property-rights theory of the firm to rationalize the determinants of integration. Different from theirs, we adopt the general-equilibrium framework of Antràs (2003) and Antràs and Helpman (2004, 2008) that pins down the relationship between industry characteristics, productivity heterogeneity, and the prevalence of vertical integration. By solving for the export share of each production mode in Chinese export processing, our theoretical predictions are largely consistent with their partial-equilibrium insights. Feenstra and Hanson estimate their model structurally, by exploring the variation in market thickness and court efficiency across Chinese regions.[6] We instead focus on the sectoral determinants of the prevalence of integration based on a more reduced-form but more general empirical model.

Using data from assembly trade in a developing country, our paper adds to the existing empirical literature on the determinants of arm's-length trade versus vertical integration in developed countries. Antràs (2003), Yeaple (2006), Bernard et al. (2008), and Nunn and Trefler (2011) are important precursors in this literature. They examine the effects of headquarters inputs, productivity dispersion and contractibility of inputs on intra-firm imports as a share of total imports in the U.S. Bernard et al. (2008) use a new measure of product contractibility based on the importance of intermediaries in international trade. Nunn and Trefler (2011) explore the varying degree of relationship specificity of different kinds of physical capital, and use new data to take into account U.S. intra-firm imports that are shipped from foreign parents of U.S. subsidiaries. Recent studies use firm-level data to examine empirically the theory of intra-firm trade. Defever and Toubal (2007) and Corcos et al. (2008) provide evidence from France, while Kohler and Smolka (2009) provide evidence from Spain. These studies

[4] We take the property-rights approach to study the determinants of vertical integration. The determinants of multinational firm boundaries can be analyzed by other theories of the firm. Existing research has applied the incentive-systems approach of Holmstrom and Milgrom (1994), and the authority-delegation approach of Aghion and Tirole (1997) to study the general equilibrium patterns of foreign integration and outsourcing. For the incentive-systems approach, see Grossman and Helpman (2004), among others. For the authority-delegation approach, see Marin and Verdier (2008, 2009) and Puga and Trefler (2003), among others.

[5] 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. (2008) and Ornelas and Turner (2009), among others. See Antràs (2011) for a survey of the literature.

[6] There is also a literature that studies the spatial determinants of FDI, such as supplier and market access. See, among others, Head and Mayer (2004) for evidence from Europe and Amiti and Smarzynska Javorcik (2008) for evidence from China. Our analysis abstracts away from these spatial determinants.

Table 1
Export shares across trade regimes (2005).
Source: Authors' calculations based on Chinese export data from the Customs General Administration of the People's Republic of China.

	Total			
	All ownership types	Processing trade	Pure-assembly	Import-assembly
Billion USD	731.27	416.48	83.90	332.60
Share of total exports	100.00%	56.93%	11.47%	45.48%
Foreign-invested enterprises				
BIllion USD	432.91	346.62	43.65	302.97
Share of total exports	100%	80.07%	10.08%	69.98%

find empirical support for the predictions of productivity ranking across production modes that involve different ownership arrangements.

In these empirical studies, imports within multinationals' boundaries are assumed to be shipped from foreign subsidiaries to the headquarters. However, it has been argued that a significant share of the intra-firm imports originates from the foreign headquarters of U.S. subsidiaries, especially from rich countries (Nunn and Trefler, 2011). Our paper considers exports from export processing assembly plants that produce exclusively for sales in countries where the headquarters are located. By focusing on exports from the subsidiaries to the multinational headquarters, we hope to obtain cleaner results to validate the existing theoretical models, which have so far focused primarily on the sourcing decisions of the headquarters in the North.

The paper is organized as follows. Section 2 briefly discusses the background of export processing in China. Section 3 develops the theoretical model for our empirical investigation. Section 4 describes the data for our analysis. Section 5 presents empirical results. The last section concludes.

2. Export processing in China

To acquire foreign technology, boost employment, and stimulate economic growth, the Chinese government has implemented various policies to promote exports and foreign direct investment since the early 1980s. One of the key policies is to provide tax incentives to encourage processing trade, which has been regulated by China's Customs under two regimes: pure-assembly and import-assembly.[7] Since then, export processing has been a main driver of the impressive export growth in China. Table 1 shows that export processing accounted for about 57% of China's total exports in 2005 and over 80% of foreign-invested enterprises' exports. Between the two processing regimes, import-assembly accounted for 45.5% of China's total exports, with pure-assembly contributing only 11.5%. Table 2 shows the distribution of processing export volume across the four production modes we study. 78% of processing exports was accounted for by import-assembly, under which the Chinese assembly plants control the purchase and the use of imported inputs. Foreign-invested plants accounted for 76% (i.e., 59.71/78.11) of the import-assembly exports, and for 44% of the pure-assembly exports (9.67/21.89). In sum, the “split” structure, which involves the foreign investor owning the plant's assets and the assembly plant controlling (not necessarily owning) the imported inputs, is the most common production mode in Chinese processing trade. This production arrangement is also emphasized by Feenstra and Hanson (2005).

There are a number of important differences between the two regimes that matter for our analysis. The first difference is related to the responsibilities of the Chinese plant. This difference is also what defines the regime types. Under pure-assembly, the main role of a Chinese manager is assembling. A foreign final-good producer supplies a Chinese assembly plant with all intermediate inputs from abroad. The plant simply assembles inputs into final products for exports. Under import-assembly, an assembly plant is responsible for purchasing intermediate inputs from abroad, instead of passively receiving them from the foreign client. An import-assembly plant is obliged to arrange the shipment and the storage of the imported inputs in bonded warehouses.

The second difference is about the ownership and control over inputs and thus the outside options of each party. Under pure-assembly, the foreign client owns and controls the inputs throughout the production process. The Chinese plant may be given temporary control rights, but will never have ownership of the inputs. Under import-assembly, the assembly plant controls the imported inputs throughout the production process. The imported inputs have to be stored in bonded warehouses, which are under close and frequent supervision by China's Customs.[8] Upon approval, the plant can use the inputs with other foreign clients. In this sense, the import-assembly plant generally has a higher outside option than a pure-assembly plant.[9]

The third difference has to do with the approval standards. Due to the flexibility of using the imported materials for multiple foreign clients, assembly plants would have larger incentives to register as an import-assembly plant. In practice, it is generally more difficult to obtain a license to operate under this regime. Moreover, the Chinese authorities require the import-assembly plants to maintain a certain standard for both accounting practices and warehouse facilities. For pure-assembly plants, there is no corresponding requirement. Under both regimes, an assembly plant needs to show the Chinese authorities the terms of transactions specified in written contracts every month. As such, the Chinese government imposes frequent checks on the behavior of the plant and ensures that it follows the requirements for each regime.[10]

The assembly plant under either regime can be independent or foreign-owned. Several remarks about foreign ownership (integration)

[7] Processing firms import intermediate inputs duty free, as long as the produced output is exported. They are also exempted for value-added taxes. Since imports are duty-free, firms have high incentives to apply to operate their production units under. Therefore, China's Customs is particularly restrictive about the use of imported materials by the processing plants. Monthly reports need to be delivered to the customs to show that imported materials are used solely for export processing. Readers are referred to Naughton (1996) and Feenstra and Hanson (2005) for a more detailed description of the two regulatory regimes.

[8] If an import-assembly assembly plant is owned by a foreign investor, the investor does have residual rights of both the plant's assets and inventory of intermediate inputs. What we emphasize here is the control rights over inputs. One may argue that for foreign-owned firms under import-assembly, the Chinese Customs may not be able to enforce the input-purchase decisions made solely by the assembly plant. Article 9 of “Regulations Concerning Customs Supervision and Control over the Inward Processing and Assembling Operation (Amended)” (http://english.mofcom.gov.cn/) says the following: “The processing enterprises concerned shall, in the special book accepted by the Customs, keep detailed records of the disposal of the materials, parts and equipment imported and the finished products exported under the contract. The Customs shall, at any time deemed necessary, examine the relevant books and correspondence as well as bonded warehouses and workshops, and the processing enterprise shall provide the customs with necessary facilities.”

[9] See Feenstra and Hanson (2005) and “Measures on the Administration of the Customs of the People's Republic of China for Bonded Warehouse Factory Engaged in Processing Trade,” Customs General Administration (http://english.mofcom.gov.cn/).

[10] See “Regulations Concerning Customs Supervision and Control over the Inward Processing and Assembling Operation,” Customs General Administration (http://english.mofcom.gov.cn/).

Table 2
Export shares of the 4 ownership-trade-regime production modes (2005).
Source: Authors' calculations based on Chinese export data from the Customs General Administration of the People's Republic of China.

		Organizational forms		
		Integration (V)	Outsourcing (O)	
Input control	Pure-assembly (N)	9.67%	12.22%	21.89%
	Import-assembly (S)	59.71%	18.40%	78.11%
		69.38%	30.62%	100%

are in order. Under the Chinese government's classification, a firm that has over 25% foreign equity is considered as foreign. It can be argued that equity ownership is positively related to control. However, our theoretical model does not equate ownership with control. As in Antràs and Helpman (2004) and Feenstra and Hanson (2005), foreign ownership in our model simply means that the foreign owner has property rights of the plant's residual profits. Control rights over processing activities always reside with the assembly plant. Under import-assembly, the input-purchase decisions are always made independently by the assembly plant, even for those that are foreign-owned. In the theoretical model below, we specify formally, using a property-rights model, how a headquarter firm can influence the decisions of its subsidiary.[11]

3. A theoretical model

3.1. Model setup

To guide our empirical analysis that involves four production modes (outsourcing versus integration, import-assembly versus pure-assembly), we develop a heterogeneous-firm model based on Antràs and Helpman (2004). We incorporate investment decisions for input purchases, which are important in processing trade. Similar to Feenstra and Hanson (2005), we postulate that in export processing, control over imported inputs provides "incentivizing" effects similar to asset ownership. We formally analyze the organizational choices of multinational production involving assembly plants in developing countries, when ownership of the plants' assets as well as control over imported inputs are to be chosen simultaneously by the final-good producer. We highlight the key features that deliver the main empirical predictions, referring the readers to the Appendix A and Antràs and Helpman for details.

Our assumptions of preferences, market structure, and firm heterogeneity are similar to Melitz (2003) and Helpman et al. (2004). Consider an environment in which all consumers have the same constant-elasticity-of-substitution preferences over 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.[12]

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: input-purchasing activities m, assembly activities a and headquarter services h, according to the following production function:

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

where θ is firm productivity, $0<\eta^m<1$, $0<\eta^a<1$ and $\eta^h = 1-\eta^m-\eta^a$.[13] 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 processing trade, a is always chosen by A in the South, while h is always chosen by H in the North. Denote by w_N the unit cost of investment in h , and by $w_S<w_N$ that for investment in a in the South.

Depending on the trade regime under which the joint production unit operates, either A or H can invest in input purchases. Under pure-assembly, H invests in both headquarter activities (h) and input purchases (m), while A invests only in assembly activities (a). Under import-assembly, H invests in h, while A invests in both a and m. This arrangement has also been analyzed by Feenstra and Hanson (2005).

For simplicity, we focus on the analysis of H's decisions between foreign outsourcing and foreign vertical integration (i.e., FDI), leaving out the analysis on the domestic sourcing modes for which we do not have data. Irrespective of the trade regime, components are always imported from abroad, reflecting what export processing plants do.

A foreign client H can choose to source assembly tasks either under the pure-assembly regime (N) or under the import-assembly regime (S); and within each regime, H can choose to outsource (O) to an assembly plant or integrate (V) with it. In sum, there are altogether four production modes that H can operate her production, denoted in short-hand notation by NV, NO, SV and SO.

Denote by f_{lk} the fixed costs in terms of N's labor units for trade regime l and organization form k, where $l\in\{S,N\}$ and $k\in\{V,O\}$. We assume that the fixed cost for integration is higher than that for outsourcing within each trade regime (i.e., $f_{lV}>f_{lO}$ for $l=S,N$), following Antràs and Helpman (2004).[14] Furthermore, we assume that pure-assembly is associated with a higher fixed cost than import-assembly for both organizational modes (i.e., $f_{Nk}>f_{Sk}$ for $k=O$ or V). This implies that pure-assembly entails higher overhead fixed costs for managing overseas procurement staff and transporting intermediate inputs to China, compared to import-assembly. However, one can argue for the opposite ranking based on higher accounting and warehouse standards required by the Chinese customs for import-assembly (see Section 2). By assuming $f_{Nk}>f_{Sk}$ for $k=O$ or V, we essentially assume that the extra overhead costs for pure-assembly exceed those associated with licensing and maintaining the required standards for import-assembly. In sum, we have the following ranking of fixed costs f's:[15]

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

[11] In practice, the plant's input-purchase decisions can be influenced by the foreign headquarter in other ways. For instance, the current incomplete-contracting model can be extended to allow partial contractibility, in which the headquarter firm can sign a (employment) contract to specify the level of investment of certain activities.

[12] $\alpha = \frac{\sigma-1}{\sigma}$, where σ is the elasticity of substitution between varieties. 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. μ is assumed to be smaller than α, i.e., products are less substitutable than varieties.

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

[14] How the fixed costs f_k's differ across organization modes k deserves more discussion. 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. By assuming that $f_V>f_0$, Antràs and Helpman (2004) essentially assume that managerial overload from managing overseas employees offsets the cost advantage arising from economies of scope of these activities.

[15] 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 $f_{NV}<f_{SV}$ and $f_{NV}<f_{NO}$. For simplicity, we do not explore these possibilities.

As in Antràs and Helpman (2004) and Feenstra and Hanson (2005), the division of ex-post surplus from the relationship are determined by Nash bargaining. Denote by $\beta\in(0,1)$ the primitive bargaining power of H, and by $(1-\beta)$ that of A.

3.1.1. Equilibrium

We solve the model backwards for the subgame-perfect equilibrium for a firm, taking sector-level variables as given. Based on the demand function above, the revenue of the joint production unit between the final-good producer and the assembly plant is

$$R(m,a,h) = D^{1-\alpha}\theta^{\alpha}\left(\frac{m}{\eta^m}\right)^{\alpha\eta^m}\left(\frac{a}{\eta^a}\right)^{\alpha\eta^a}\left(\frac{h}{\eta^h}\right)^{\alpha\eta^h}. \tag{3}$$

At the bargaining stage, the outside option of each party depends on both the organizational form (V or O) as well as the trade regime (N or S). Different outside options in turn affect the de-facto shares of the ex-post surplus for each party. We now discuss the resulting surplus under different production modes.

3.1.1.1. Pure-assembly. In the pure-assembly regime, H retains ownership and control over the imported components. If H decides to vertically integrate with assembly plant A (the NV mode), H retains the right to fire the manager of A and seize her relationship-specific inputs. If bargaining fails, H can then use A's inputs to assemble the imported components into finished products with another plant. However, to the extent that A has accumulated relationship-specific assets, she is more efficient than an outside manager. H therefore incurs an efficiency loss in production without A. To fix ideas, we assume that H can complete only a fraction $\delta\in(0,1)$ of the original output, implying an outside option (threat point) of $\delta^{\alpha}R<R$. Without loss of generality, A's outside option is normalized to 0. In other words, A's investments are assumed to be completely specific to H, as in Antràs and Helpman (2004).[16]

In the case of outsourcing, if bargaining fails, H does not own A's assets to complete production. Her outside option is normalized to 0 symmetrically. It can be argued that given H's ownership of imported components in this regime, she can use the components to produce with another plant. What we have in mind here is that once the components are shipped to A, the value of the components drops significantly.[17] Normalizing H's outside option to 0 is a simplifying assumption. Our results are robust to an assumption of a positive but sufficiently low outside option for H.[18]

Denote by β_{NV} H's expected share of the joint surplus under integration, with $(1-\beta_{NV})$ being the expected share for A. Similarly, denote by β_{NO} H's expected share of the joint surplus under outsourcing. The above discussion implies the following:

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

Denote by $w_N\lambda_N$ the cost of component purchases, where λ_N captures H's efficiency in procuring components. Under pure-assembly, H solves $\max_{m,h}\{\beta_{Nk}R(m,a,h)-w_N\lambda_N m-w_N h\}$, whereas A solves $max_a\{(1-\beta_{Nk})R(m,a,h)-w_S a\}$. For organizational form $k\in\{V,O\}$, solving H's and A's problems simultaneously gives the profit-maximizing levels a^*, h^* and m^* in terms of w_S, w_N, λ, θ, D, η's and importantly, β_{Nk}. Using the solutions to the problems and Eq. (3), we can express the joint production unit's profits as

$$\pi_{Nk} = D\Theta\psi_{Nk} - w_N f_{Nk}, \tag{4}$$

where $\Theta \equiv \theta^{\frac{\alpha}{1-\alpha}}$, f_{Nk} is the fixed cost of production and

$$\psi_{Nk} = \frac{1-\alpha\left[\beta_{Nk}\eta^m + \beta_{Nk}\eta^h + (1-\beta_{Nk})\eta^a\right]}{\left[\frac{(\lambda_N)^{\eta^m}}{\alpha}\left(\frac{w_S}{1-\beta_{Nk}}\right)^{\eta^a}\left(\frac{w_N}{\beta_{Nk}}\right)^{\eta^h+\eta^m}\right]^{\frac{\alpha}{1-\alpha}}}.$$

ψ_{Nk} reaches its maximum when

$$\beta_N^*(\eta^a) = \frac{(1-\alpha\eta^a)(1-\eta^a)-\sqrt{\eta^a(1-\alpha\eta^a)(1-\eta^a)(1-\alpha(1-\eta^a))}}{1-2\eta^a},$$

where $\beta_N^{*\prime}(\eta^a)<0$. Given that $\eta^a = 1-(\eta^h+\eta^m)$, $\beta_N^{*\prime}(\eta^h+\eta^m)>0$. A higher headquarter-intensity is associated with a higher optimal $\beta_N^*(\eta^a)$.

3.1.1.2. Import-assembly. In the import-assembly regime, A invests in input purchases and business relationships with overseas component suppliers. If bargaining fails, A can capitalize her intangible assets associated with the input procurement activities by working with another firm in the North. Similar to Feenstra and Hanson (2005), we assume, admittedly in an abstract fashion, that A obtains a share $\gamma\in(0,1)$ of revenue when bargaining fails, independent of the production unit's ownership structure.

Similar to the discussion above, in an integrated firm, H can seize A's assets to complete production with a third-party plant if bargaining fails. She then obtains an outside option of $\delta^{\alpha}R$. In the case of outsourcing, H does not own either A's assets or components. Her outside option, similar to outsourcing under pure-assembly, is normalized to 0. However, A can capitalize her intangible asset associated with input-purchasing experience, obtaining an outside option of γR. Let us denote by β_{SV} and β_{SO} H's expected shares of the joint surplus for integration and outsourcing under import-assembly, respectively. We have[19]:

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

Note that $\beta_{NV}>\beta_{SV}>\beta_{SO}$. If we further assume that asset ownership is sufficiently more effective in alleviating hold-up by the assembly plant, that is, $\delta^{\alpha}(1-\beta)>\gamma$, we have $\beta_{SV}=\beta(1-\gamma)+(1-\beta)\delta^{\alpha}>\beta=\beta_{NO}$.

The input purchasing cost in this regime is $w_S\lambda_S$, where λ_S captures A's efficiency in procuring components. Anticipating ex-post bargaining, H solves $\max_h\{\beta_{Sk}R(m,a,h)-w_N h\}$, whereas A solves $\max_{a,m}\{(1-\beta_{Sk})R(m,a,h)-w_S\lambda_S m-w_S a\}$. For organizational form $k\in\{V,O\}$, solving H's and A's problems simultaneously gives the profit-maximizing investment levels a^*, h^* and m^* in terms of w_S, w_N, λ_S, λ_N, θ, D, η's, and β_{Sk}. Using these solutions and Eq. (3), we obtain the joint production unit's profits for organization mode k under import-assembly as

$$\pi_{Sk} = D\Theta\psi_{Sk} - w_N f_{Sk}, \tag{5}$$

[16] 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. See Antràs and Helpman (2008) for an analysis that allows for partial specificity of investments.

[17] One can also argue that outside the relationship with A, H can capitalize the business networks or other intangible assets associated with input purchases. Once the inputs are shipped to A, H's experience in input-purchasing and business network with foreign input-suppliers probably do not enhance H's threat point and thus her ex-post bargaining weight.

[18] Specifically, as long as control over components raises A's outside option more than H's, all of our theoretical predictions hold.

[19] Table 3 summarizes the ex-post bargaining weights for each of the four production modes.

where $\Theta \equiv \theta^{\frac{\alpha}{1-\alpha}}$, and

$$\psi_{Sk} = \frac{1-\alpha\left[\beta_{Sk}\eta^h + (1-\beta_{Sk})\left(1-\eta^h\right)\right]}{\left[\frac{(\lambda_S)^{\eta^m}}{\alpha}\left(\frac{w_S}{1-\beta_{Sk}}\right)^{1-\eta^h}\left(\frac{w_N}{\beta_{Sk}}\right)^{\eta^h}\right]^{\frac{\alpha}{1-\alpha}}}.$$

ψ_{Sk} reaches its maximum when

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

Notice that $\beta_S^{*\prime}(\eta^h) > 0$. A higher headquarter-intensity is associated with a higher optimal $\beta_S^*(\eta^h)$.

3.1.2. Choosing optimal production modes

Conditional on staying in the market, H chooses the production mode to maximize her objective as follows:

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

This also turns out to be the expected profit of the joint production unit.[20] H's choices depend on the slopes of π_{lk} (ψ's) and the fixed costs f_{lk}'s for different production modes lk.

Recall that for a given η^m, $\beta_N^{*\prime}(\eta^a)<0$ and $\beta_S^{*\prime}(\eta^a)<0$. Thus, β_{lO} is preferred to β_{lV} within each trade regime $l\in\{N,S\}$ for sufficiently low η^a. In words, in an assembly-intensive sector (i.e., a sector that has $\beta_l^*(\eta^a) \le \beta_{lO} < \beta_{lV}$ for $l\in\{N,S\}$), integration would not be chosen as an optimal production mode.

On the other hand, in a headquarter-intensive sector (i.e., a sector that has $\beta_l^*(\eta^a) \ge \beta_{lV} > \beta_{lO}$ for $l\in\{N,S\}$), both integration and outsourcing can be the optimal organization modes within each regime. Fig. 1, which plots firms' profits on productivity, illustrates our baseline case when all four production modes coexist in a headquarter-intensive sector. Firms with productivity term Θ below the cutoff Θ_{SO} exit, those with $\Theta\in[\Theta_{SO},\Theta_{SV})$ outsource under import-assembly, those with $\Theta \in[\Theta_{SV},\Theta_{NO})$ integrate under import-assembly, those with $\Theta\in[\Theta_{NO},\Theta_{NV})$ outsource under pure-assembly, and finally those with $\Theta \ge \Theta_{NV}$ integrate under pure-assembly.

The coexistence of all four production modes implies a specific ranking of $\psi'_{lk}s$. Within each trade regime, since integration always gives more investment incentives to the headquarter, $\psi_{lV} > \psi_{lO}$ for $l\in\{N,S\}$. Recall that the ranking of $\psi'_{lk}s$ ultimately depends on $\beta'_{Sk}s$ and the input prices: w_N, w_S, λ_N, and λ_S. On the one hand, for a given organizational mode (k), giving H control over imported inputs under pure-assembly gives her more incentives to invest in headquarter activities compared with import-assembly (i.e., $\psi_{Sk} < \psi_{Nk}$). On the other hand, lower w_S can make A's procurement of imported inputs and thus import-assembly more attractive than pure-assembly for H. For a given component intensity η^m, assuming sufficiently low marginal costs of input purchases in the North relative to the South (see Appendix A for a formal statement),[21] we have the following ranking of profitability:

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

[20] Upon matching up, H pays A an ex-ante transfer. An inelastic supply of A's implies that H will adjust the transfer to make the latter just indifferent between joining the production unit and staying out. The payoff of staying-out is associated with a certain payoff of 0. Under these circumstances, H's ex-ante objective turns out to be exactly the same as the joint production unit's profits.

[21] In Antràs and Helpman (2004), production modes in the North are associated with highest bargaining weights than those for the South. But then they assume that high wages in the North would make the South production modes more profitable in terms of operating profits.

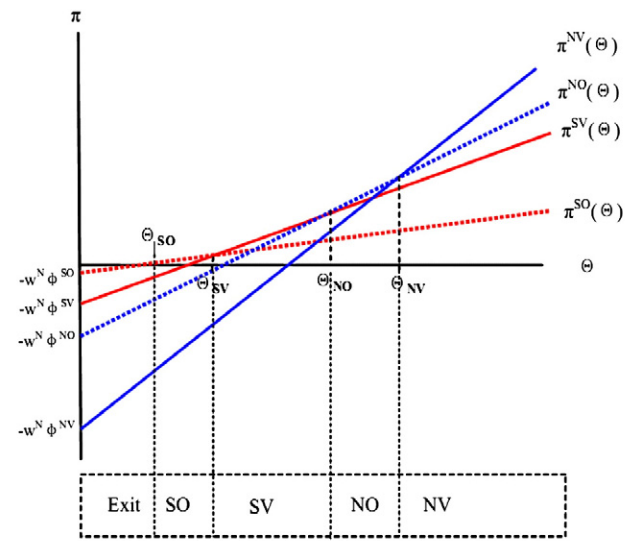

Fig. 1. Co-existence of four production modes in a headquarter-intensive sector.

which supports the sorting of firms into different production modes illustrated in Fig. 1. Suppose A's marginal cost of input purchasing is sufficiently low (e.g., low w_S), pure-assembly is dominated by import-assembly, the ranking of ψ's can become $\psi_{SV} > \psi_{SO} > \psi_{NV} > \psi_{NO}$. Given the ranking assumption of fixed costs (Eq. (2)), there would be no plants operating under pure-assembly in equilibrium. Importantly, our main empirical results do not depend on assumption (6).

3.1.3. Export shares

To derive closed-form expressions for the export shares in each trade mode, we follow Helpman et al. (2004) and assume a Pareto distribution of Θ, with cumulative distribution function $G(\Theta) = 1-\left(\frac{\Theta_{min}}{\Theta}\right)^{\kappa}$, where $\kappa > 2$ and $\Theta \ge \Theta_{min} > 0$. Since integration is never chosen in an assembly-intensive sector, the market share of integrated exports is 0. The productivity cutoffs for each production mode can be obtained by solving a set of indifference conditions. For instance, H with productivity parameter Θ_{SV} should be indifferent between the SV mode and the NO mode, i.e., $\pi_{SV}(\Theta_{NO}) = \pi_{NO}(\Theta_{NO})$. Solving the set of indifference conditions gives:

$$\Theta_{SO} = \frac{Bf_{SO}}{\psi_{SO}}; \quad \Theta_{SV} = \frac{B(f_{SV}-f_{SO})}{\psi_{SV}-\psi_{SO}}$$
$$\Theta_{NO} = \frac{B(f_{NO}-f_{SV})}{\psi_{NO}-\psi_{SV}}; \quad \Theta_{NV} = \frac{B(f_{NV}-f_{NO})}{\psi_{NV}-\psi_{NO}},$$

where $B = w_N/D$. Our baseline ranking assumptions (2) and (6) guarantee that all these cutoffs are positive.

Under the distribution assumption of Θ, the export value of each production mode can then be solved as:

$$X_{SO} = D\Gamma\varphi_{SO}\left(\Theta_{SO}^{1-\kappa} - \Theta_{SV}^{1-\kappa}\right); \quad X_{SV} = D\Gamma\varphi_{SV}\left(\Theta_{SV}^{1-\kappa} - \Theta_{NO}^{1-\kappa}\right)$$
$$X_{NO} = D\Gamma\varphi_{NO}\left(\Theta_{NO}^{1-\kappa} - \Theta_{NV}^{1-\kappa}\right); \quad X_{NV} = D\Gamma\varphi_{NV}\Theta_{NV}^{1-\kappa},$$

where $\Gamma \equiv \frac{\kappa\Theta_{min}^{\kappa}}{\kappa-1}$ and ϕ_lk is the denominator of ψ_lk. Before analyzing the relationship between η^h and the export share of each production mode, let us introduce the following lemma that helps us prove the main results of the paper.

Lemma. *For organization mode k,* $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h} \ge 0.$

Proof. See Appendix A.

Similarly, we can show that $\frac{d\left(\ln\frac{\psi_{lV}}{\psi_{lO}}\right)}{d\eta^h} \ge 0$ for trade regime l; and since we assume that asset ownership is more effective in alleviating hold-up compared to input control (i.e., $\beta_{SV}>\beta_{NO}$), we can show that $\frac{d\left(ln\frac{\psi_{SV}}{\psi_{NO}}\right)}{d\eta^h}\geq 0$.

The export share of integrated import-assembly processing plants in total processing exports can be expressed as

$$s_{SV}=\frac{X_{SV}}{\sum_{l=N,S;k=V,O}X_{lk}}=\left[\frac{X_{SO}}{X_{SV}}+\frac{X_{NO}}{X_{SV}}+\frac{X_{NV}}{X_{SV}}+1\right]^{-1}, \tag{7}$$

whereas the export share of integrated pure-assembly plants in total processing exports is

$$s_{NV}=\frac{X_{NV}}{\sum_{l=N,S;k=V,O}X_{lk}}=\left[\frac{X_{SO}}{X_{NV}}+\frac{X_{NO}}{X_{NV}}+\frac{X_{SV}}{X_{NV}}+1\right]^{-1}. \tag{8}$$

Simple comparative statics show that $\frac{X_{SO}}{X_{SV}}$, $\frac{X_{NO}}{X_{SV}}$, $\frac{X_{SO}}{X_{NV}}$, and $\frac{X_{NO}}{X_{NV}}$ are all decreasing in η^h.[22] Thus, we know that the export share of foreign-owned plants ($s_{SV}+s_{NV}$) is increasing in η^h. This result implies that either s_{SV}, s_{NV}, or both need to be increasing in η^h.

The ratio $\frac{X_{SV}}{X_{NV}}$, which appears in both Eqs. (7) and (8) but in a reverse manner, plays a key role in determining the relationship between η^h, s_{NV}, and s_{SV}.[23] However, the impact of a higher η^h on $\frac{X_{NV}}{X_{SV}}$ is ambiguous since $\frac{\varphi_{NV}}{\varphi_{SV}}$ is increasing in η^h, but $\frac{\Theta_{NV}}{\Theta_{NO}}$ is also increasing in η^h whereas $\frac{\Theta_{NV}}{\Theta_{SV}}$ can be increasing or decreasing in η^h.

Fig. 2 depicts how the productivity cutoffs Θ_{lk} and the envelope of firms' profits (captured by ψ_{lk}) move when η^h increases. It shows that X_{SV} (the area enclosed by the profit envelope, Θ_{SV}, and Θ_{NO}) and X_{NV} (the area enclosed by the profit envelope, Θ_{NV}, and Θ_{NO}) both expand when η^h increases. The impact of a higher η^h on $\frac{\Theta_{NV}}{\Theta_{SV}}$ and thus the relation between η^h and s_{SV} and that between η^h and s_{NV} are ambiguous. Graphically, if the decline of Θ_{NV} is sufficiently less than that of Θ_{SV} (see Appendix A for a formal statement), $\frac{d\left(\frac{X_{SV}}{X_{NV}}\right)}{d\eta^h}$ can be sufficiently positive so that s_{SV} is increasing in η^h while s_{NV} is decreasing in η^h (see inequality (13) in the Appendix A).

Intuitively, a sufficiently large increase in $\frac{X_{SV}}{X_{NV}}$ requires integration to be associated with a sufficiently smaller rise in the production unit's profitability when imported components are controlled by H (pure-assembly) than by A (import-assembly). As such, the export share of import-assembly foreign-invested plants over total processing exports increases in η^h, whereas the share of foreign firms in the pure-assembly regime declines. While our model proposes that input control is less effective than asset ownership in alleviating hold-up by assembly plants, it does serve as an alternative for that purpose. When the headquarter intensity of production increases, a final-good producer who designates an assembly plant to procure components (import-assembly) would be more vulnerable to hold-up than those who at least control the inputs (pure-assembly). Thus, the gain from integration is larger for a final-good producer who does not have input-control than one who does. Our results resonate with a key theoretical result in Feenstra and Hanson (2005), who show that the increase in the returns to giving the assembly plant control over inputs is larger when the plant does not own assets than when it does. Based on this theoretical result, the authors rationalize the prevalence of the "split" ownership structure in China's processing trade, as our Table 2 also shows.

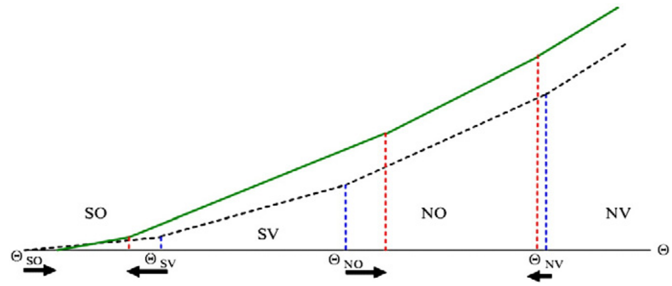

Fig. 2. Graphical representation of the comparative statics of an increase in η^h on ψ's and the productivity cutoffs.

We will use disaggregated product-level data to examine the following theoretical prediction.

Prediction 1- *Headquarter intensity and the prevalence of vertical integration:*

1. The export share of vertically integrated (VI) plants in total export processing is *increasing* in the sector's headquarter intensity (η^h).
2. If the incremental gain from integration is sufficiently smaller with input control than without, the export share of VI plants under import-assembly is *increasing* in η^h, whereas that under pure-assembly is *decreasing* in η^h.

Notice that if we examine the fractions of different types of plants in total number of processing plants (N_{lk}/N) like in Antràs and Helpman (2004), the fractions of NV and SV are both increasing in η^h. Specifically, $N_{SO}/N=1-\left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}$; $N_{SV}/N=\left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa}\left[1-\left(\frac{\Theta_{SV}}{\Theta_{NO}}\right)^{\kappa}\right]$; $N_{NO}/N=\left(\frac{\Theta_{SO}}{\Theta_{NO}}\right)^{\kappa}-\left(\frac{\Theta_{SO}}{\Theta_{NV}}\right)^{\kappa}$; $N_{NV}/N=\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{\kappa}$. Given data on export volume, we use export shares, instead of fractions of exporters in each production mode, as the dependent variable to examine Prediction 1 below.

Our model also predicts that in a headquarter-intensive sector, firms under pure-assembly are more productive than those under import-assembly. Moreover, only the most productive firms find it profitable to engage in vertical integration under pure-assembly. Specifically, our model predicts that when the distribution of firm productivity becomes more dispersed (i.e., more clustered on the right tail), the export share of integrated plants in the pure-assembly regime should increase. However, the relationship is ambiguous in the import-assembly regime. We will also examine the following prediction (see Appendix A for the proof).

Prediction 2- *Productivity dispersion and the prevalence of vertical integration:*

In a headquarter-intensive sector, a higher firm productivity dispersion is associated with a larger export share of the foreign firms that operate under the pure-assembly regime. The relationship is ambiguous under the import-assembly regime, and is absent in an assembly-intensive sector.

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 for 2005.[24] The data report values in US dollars for imports and exports of over 7000 products in the HS 6-digit classification,[25] 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),

22 $\frac{X_{SO}}{X_{SV}}=\frac{\varphi_{SO}}{\varphi_{SV}}\frac{\left(\frac{\Theta_{SV}}{\Theta_{SO}}\right)^{\kappa-1}-1}{1-\left(\frac{\Theta_{SV}}{\Theta_{NO}}\right)^{\kappa-1}}$; $\frac{X_{NO}}{X_{SV}}=\frac{\varphi_{NO}}{\varphi_{SV}}\frac{1-\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{\kappa-1}}{\left(\frac{\Theta_{NO}}{\Theta_{SV}}\right)^{\kappa-1}-1}$; $\frac{X_{SO}}{X_{NV}}=\frac{\varphi_{SO}}{\varphi_{NV}}\left(\frac{\Theta_{NV}}{\Theta_{SO}}\right)^{\kappa-1}\left[1-\left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa-1}\right]$; $\frac{X_{NO}}{X_{NV}}=\frac{\varphi_{NO}}{\varphi_{NV}}\left[\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)^{\kappa-1}-1\right]$

23 $\frac{X_{SV}}{X_{NV}}=\frac{\varphi_{SV}}{\varphi_{NV}}\left[\left(\frac{\Theta_{NV}}{\Theta_{SV}}\right)^{\kappa-1}-\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)^{\kappa-1}\right]$.

24 We purchased these data from Mr. George Shen from China Customs Statistics Information Center, Economic Information Agency, Hong Kong.

25 Example of a product: 611241—Women's or girls' swimwear of synthetic fibres, knitted or crocheted.

Table 3
Export bargaining shares of revenue of the 4 ownership-regime production modes.

β_{lk}		Organizational forms *(k)*	
		Integration (V)	Outsourcing (O)
Input control *(l)*	Pure-assembly (N)	$\delta^{\alpha}+\beta(1-\delta^{\alpha})$	β
	Import-assembly (S)	$\delta^{\alpha}+\beta(1-\gamma-\delta^{\alpha})$	$\beta(1-\gamma)$

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").[26] 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-assembly). Regular trade is classified by China Customs Statistics according to the regime "Ordinary Trade".

We use two dependent variables. The first one is the share of processing exports from foreign-owned assembly plants over total processing exports at the HS 6-digit product level (or product-country level). The second one is the share of processing exports from foreign-owned assembly plants in each trade regime $l=N, S$ (pure-assembly or import-assembly, respectively) separately over total processing exports at the HS 6-digit product level (or product-country level). The Chinese government considers two types of foreign-invested enterprises, fully foreign-owned enterprises and Sino-foreign equity joint ventures. We consider both of these types of enterprises as "foreign owned".[27] Results remain robust when we consider only fully foreign-owned enterprises.

Our key independent variables are various measures of headquarter intensity. Following the existing empirical literature on the determinants of intra-firm trade, such as Antràs (2003), Yeaple (2006), Bernard et al. (2008) and Nunn and Trefler (2008, 2011), we use skill and physical capital intensities as our proxies for the importance of headquarter services in production. The measures of industry factor intensity are constructed using data from Bartelsman and Gray (1996), averaged across the period 2001–2005.[28] For each 4-digit SIC industry we construct the measure of skill-intensity, $\ln(H_j/L_j)$, as the log of non-production worker wages divided by total worker wages. Physical capital intensity (total capital, $\ln(K_j/L_j)$, and the break down into capital-equipment intensity, $\ln(E_j/L_j)$, and capital-plant intensity, $\ln(P_j/L_j)$) are measured as the natural log of the corresponding capital expenditures divided by total wages.

We also include R&D intensity as an additional proxy for headquarter's inputs. We measure R&D intensity, $\ln(RD_j/Q_j)$, by the natural log of global R&D expenditures divided by firm sales in each industry. The data are from the Orbis database, constructed by Bureau van Dijk Electronic Publishing, for the most recent year for which firm level data on R&D are available (either 2006 or 2007). A total of 370,691 plants reported positive R&D expenditure. Since we are interested in studying the decisions of integration by multinational firms in 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. Material intensity, $\ln(M_j/L_j)$, is the log of the cost of materials divided by total wages.

[26] The data also report quantity, quantity units, customs offices (ports) where the transaction was processed (97 in total), and transportation modes.

[27] According to the Chinese law a firm is considered foreign owned if a foreign partner has no less than 25% of ownership stake. In the U.S. Census Bureau data, U.S imports are classified as "related-party" if either firm owns, controls or holds voting power equivalent to 6% of the shares or voting stock of the other organization. Existing studies that have used U.S. Census Bureau data to investigate the determinants of intra-firm trade use "related-party" imports to measure intra-firm trade.

[28] 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 use U.S. factor intensities of production, assuming that they are correlated with the corresponding factor intensities in other countries, following existing literature. To check the robustness of our results, we also construct measures of physical capital, skill, and R&D and advertisement intensity using plant-level data from the Chinese National Bureau of Statistics' Census of Industrial Firms for 2005. Restricted by data availability, the definitions of these factor intensity measures are different from the US-based benchmark measures. Capital intensity is defined as the log ratio of the real value of capital to the real value of output in each sector. Human capital is the log of the share of high-school graduates in the workforce of each sector.[29] R&D intensity is the log average ratio of R&D expenditure to value-added across firms in each sector. Advertisement intensity is measured by the log average ratio of advertisement expenditure to value-added across firms in each sector.

We follow Helpman et al. (2004) and construct the measure of productivity dispersion using the standard deviation of firm sales across all firms within an industry. The data are from China's Manufacturing Survey for 2005. For robustness we use two alternative measures based on exports. The first one is the standard deviation of export revenue across Chinese export processing plants in each sector, using firm-level exports data for 2005 from China's Customs. The second one is the measure of industry productivity dispersion from Nunn and Trefler (2008) for 2005.[30] 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.

5. Empirical analysis

In this section we investigate whether control over the components for assembly affects the decision to integrate with the assembly plant in vertical production relationships. Namely, we examine the hypotheses emphasized in prediction 1 that (1) the export share of vertically integrated (VI) export processing plants is *increasing* in the sector's headquarter intensity and that (2) the export share of VI plants under import-assembly is *increasing* in headquarter intensity of inputs, whereas that under pure-assembly is *decreasing* in headquarter intensity. We then investigate whether a higher sectoral productivity dispersion is associated with a larger export share from integrated plants in pure-assembly, as postulated in prediction 2.

5.1. Examining the effects of headquarter intensity

To investigate the effect of headquarter-intensity of inputs on the prevalence of vertically integrated exports, we start by examining the first hypothesis from prediction 1. We estimate the following cross-industry regression both at the HS 6-digit product level and at the HS 6-digit level to each importing country to exploit both product and country dimensions of the data:

$$\left(\frac{X_{NV}+X_{SV}}{\sum_{l=N,S;k=V,O}X_{lk}}\right)_{pjc}=d_c+\gamma_h h_j+\gamma_k k_j+\gamma_m m_j+\epsilon_{pjc}, \qquad (9)$$

[29] Our results are robust to using the share of college graduates in each sector's workforce to measure skill intensity.

[30] Given the lack of firm-level data, Nunn and Trefler (2008) construct sales of "notional" firms using U.S. export data from the U.S. Department of Commerce. They define an industry as an HS6 product and the sales of a notional firm as the exports of an HS10 good exported from U.S. location l to destination country c. Their measure of productivity dispersion within an industry is the standard deviation of the log of exports of a good from location l to country c. We are grateful to Nathan Nunn for sending us the data.

Table 4
Headquarter intensity and the export share of vertically integrated plants.

	HS6-country				HS6			
	OLS		Tobit		OLS		Tobit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity, ln(H/L)	0.095***		0.253***		0.073**		0.081*	
	(3.471)		(3.032)		(2.148)		(1.956)	
Capital intensity, ln(K/L)	0.088***	0.064**	0.168***	0.134***	0.073*	0.070*	0.057**	0.056**
	(3.380)	(2.341)	(4.101)	(3.084)	(1.959)	(1.760)	(2.371)	(2.055)
R&D intensity, ln(RD/Q)		0.071***		0.048**		0.039		0.012
		(2.613)		(2.469)		(1.241)		(1.150)
Material intensity, ln(M/L)	−0.100***	−0.101***	−0.205***	−0.208***	−0.115***	−0.127***	−0.074***	−0.082***
	(−3.474)	(−3.377)	(−4.028)	(−4.033)	(−2.984)	(−3.336)	(−2.756)	(−3.034)
Country fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
N	80,474	77,181	80,474	77,181	3664	3541	3664	3541
No. clusters	349	318	349	318	349	318	349	318
R2	.035	.031	.017	.016	.016	.013	.0085	.0071
N left-censored			14,899	14,358			319	314
N right-censored			33,454	32,285			570	560

Dependent variable: China's foreign-affiliated plants' Export Processing exports as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country in columns (1) to (4) and a 6-digit HS product category in columns (5) to (8). Standardized beta coefficients are reported for OLS results. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

where p stands for product, j for industry, and c for country. V and O represent vertical integration and outsourcing, respectively; and N and S represent pure-assembly and import-assembly, respectively. The dependent variable is the share of processing exports from foreign-owned assembly plants over total processing exports at the product-country level (or at the product level) in industry j. To proxy for headquarter intensity, we use the measures of skill intensity $h_j \equiv \ln(H_j/L_j)$ and physical capital intensity $k_j \equiv \ln(K_j/L_j)$ described in the previous section.[31] In some specifications, we use R&D intensity $rd_j \equiv \ln(RD_j/Q_j)$ as an alternative measure.[32]

For robustness checks, we follow Nunn and Trefler (2011) and include capital-equipment $e_j \equiv \ln(E_j/L_j)$ and capital-plant $p_j \equiv \ln(P_j/L_j)$ in alternative to the overall measure of physical capital intensity. The former type of capital expenditures is more likely to be more relationship-specific than the latter, and therefore more relevant for the integration decision. We use material intensity $m_j \equiv \ln(M_j/L_j)$ as a proxy for the importance of components in production. We include country fixed effects d_c when observations are at the HS6-country level.[33] The error term ϵ_{pjc} is assumed to be uncorrelated with the regressors. Because our regressors of interest vary across SIC 4-digit industries, the standard errors are always clustered at the SIC 4-digit level to take into account the correlation between observations within the same SIC category.[34]

We investigate the hypothesis that exports from vertically integrated plants account for a larger share of processing exports in more headquarter-intensive sectors. Thus, the predicted signs of γ_h and γ_k are positive. Table 4 reports results from estimating (9). In columns (1) through (4) an observation is a HS6 product to each country. These specifications therefore take into account importing country characteristics such as distance from China, quality of judicial institutions and factor endowments. Since our focus is on the sectoral determinants of the export share of integrated plants, we control for country fixed effects to partial out the effects of countries' characteristics.

The results conform closely to the theoretical prediction for all the alternative measures of headquarter intensity of inputs (skill intensity, physical capital intensity, and R&D intensity). They are evidence of a strong, positive, and statistically significant correlation between the share of vertical integration and the intensity of headquarter inputs across sectors. The first two columns report OLS results and show standardized beta coefficients, while columns (3) and (4) report Tobit results.[35] The coefficients on skill and capital intensity are positive and statistically significant at the 1% level. These results confirm the main findings by Yeaple (2006), Bernard et al. (2008), Nunn and Trefler (2008, 2011), who find a positive relationship between skill and capital intensity and the share of intra-firm trade across U.S. manufacturing industries. The size of the coefficients is at the same magnitude of those reported by Nunn and Trefler (2008) for the U.S. We also find a positive and significant correlation between the share of vertical integrated exports and the sector's R&D intensity (columns (2) and (4)).[36]

As discussed in Antràs (2011) and Nunn and Trefler (2011), standard measures of physical capital include certain types of investments that are easily contractible and thus are not relationship-specific. According to the property-rights theory of the firm, it is then expected that investments in specialized equipment are more relationship-specific, and thus more relevant for the decision of whether to integrate, while structures or plants can be used to produce other goods and are therefore associated with a higher outside value.

To investigate these issues, in alternative specifications we include capital-equipment and capital-plant intensity separately in the regressions. We report results for these specifications in Appendix A, Table A4. The coefficients on skill and R&D intensity remain positive and highly significant. Capital-equipment is also positively and significantly correlated with the share of vertically integrated processing exports. Whereas the coefficients on the intensity of capital-plant are negative and statistically significant. This is consistent with the

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

[32] 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.

[33] When the analysis is performed at the HS6 product level the subscript c would be omitted from Eq. (9) and instead of country fixed-effects we include a constant term.

[34] The mapping of HS 6-digit categories to SIC 4-digit industries is discussed in detail in the Appendix.

[35] Since the vertical integrated export share dependent variables are limited between values of 0 and 1, we also report results from Tobit methods. Results are consistent with the OLS ones.

[36] R&D intensity and skill intensity are highly correlated and therefore are not included as regressors simultaneously.

Table 5
Headquarter intensity and the export share of vertically integrated plants (HS6 level).

Trade regime	Import-assembly				Pure-assembly			
	OLS		Tobit		OLS		Tobit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity, ln(H/L)	0.082***		0.107***		−0.022		−0.011	
	(2.621)		(2.702)		(−0.542)		(−0.230)	
Capital intensity, ln(K/L)	0.148***	0.108**	0.095***	0.072**	−0.136**	−0.072	−0.109***	−0.072**
	(2.836)	(2.014)	(2.796)	(1.961)	(−1.970)	(−1.043)	(−3.165)	(−2.033)
R&D intensity, ln(RD/Q)		0.112***		0.036***		−0.131***		−0.036***
		(3.293)		(3.106)		(−3.500)		(−3.652)
Material intensity, ln(M/L)	−0.115***	−0.099**	−0.074**	−0.065**	0.009	−0.039	−0.020	−0.050*
	(−2.693)	(−2.387)	(−2.474)	(−2.178)	(0.205)	(−0.857)	(−0.734)	(−1.829)
N	3664	3541	3664	3541	3664	3541	3664	3541
No. clusters	349	318	349	318	349	318	349	318
R^2	.023	.026	.013	.014	.017	.029	.049	.059
N left-censored			416	408			1646	1623
N right-censored			412	405			46	45

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category. Standardized beta coefficients are reported for OLS results. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

findings by Antràs (2011), Antràs and Chor (2011), and Nunn and Trefler (2011).

Columns (5) through (8) of Table 4 report results at the HS 6-digit product level. Skill and capital intensities remain positively and significantly correlated with the share of vertically integrated processing exports across sectors. The coefficients on R&D intensity remain positive but they are not significant. However, when we take into account the different degree of relationship specificity of different types of capital, the coefficients on R&D remain positive and statistically significant (see Table A4 in the Appendix A).

We now turn to the analysis of the relationship between headquarter-intensity of inputs and the prevalence of vertically integrated exports in each regime of export processing. We investigate the second hypothesis emphasized in Prediction 1 that the export share of integrated plants under import-assembly is *increasing* in headquarter intensity, whereas that under pure-assembly is *decreasing*. We estimate the following cross-industry regression at both HS6 and HS6-country levels of observation:

$$\left(\frac{X_{lV}}{\sum_{l=N,S;k=V,O} X_{lk}}\right)_{pjc} = d_c + \gamma_h h_j + \gamma_k k_j + \gamma_m m_j + \epsilon_{pjc}, \qquad (10)$$

l is the trade regime type that can be S (import-assembly) or N (pure-assembly). The dependent variable is the share of integrated assembly plants' exports of a HS6-digit product or HS6-country pair in industry j under trade regime l over total processing exports. All other variables are as defined before. According to Prediction 1, the expected signs of γ_h and γ_k are positive for import assembly and negative for pure assembly.

Table 5 reports results from estimating Eq. (10) for both trade regimes at the HS6 level. In columns (1) through (4) we report results for the import-assembly regime. The results confirm the theoretical prediction for all proxies of headquarter intensity (skill, physical capital and R&D). They show that when the assembly plants retain control over the component choice, the export share of vertically integrated plants is positively correlated with headquarter intensity of inputs across sectors. The coefficients on skill intensity and R&D intensity are positive and statistically significant at the 1% level. Similarly, we obtain a positive and statistically significant correlation between capital intensity and the share of vertical integration.

Material intensity is found to be negatively correlated with the integrated plants' export share in the import-assembly regime. Insights from the property-rights approach can help us explain the relationship. Under import-assembly, the control rights over the input decision 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-purchase activities. The distortion effects are bigger in more material-intensive sectors, making integration a less preferred organization mode.

The results for pure-assembly are reported in columns (5) to (8). We find no evidence of a positive correlation between the measures of headquarter intensity of inputs and the share of integrated plants' exports for this regime. The coefficients on the headquarter intensity measures are generally negative and statistically significant (with the exception of skill intensity which is negative but insignificant). In sum, the results reported in Table 5 are consistent with the predictions of the theoretical model as skill, R&D and physical capital are all positively and significantly correlated with the share of exports from vertically integrated plants in the import-assembly regime. The negative relationship for the pure-assembly regime arises because when the gains from integration are smaller for the headquarter firm without input controls (import-assembly) than with it (pure-assembly), the volume of exports from import-assembly expand more than that from pure-assembly, causing a decline in the share of exports in the pure-assembly regime in total processing exports.

Since we have used export shares of a product aggregated across importing countries, the above results do not take into account importing country characteristics. Thus, we also perform the analysis using unilateral export value in a HS 6-digit product category to each importing country as the unit of observation. Table 6 reports results which are consistent with those reported in Table 5. In particular, for the import-assembly regime (columns (1) to (4)), we continue to find a positive and statistically significant relationship (at the 1% level) between the share of integrated plants' exports and all measures of intensity of headquarter inputs (skill, R&D and capital).[37] For pure-assembly (columns (5) to (8)), we continue to find evidence of a negative correlation between headquarter intensity of inputs and vertical integration.

[37] Results are robust to including capital-equipment and capital-plant instead of the overall measure of physical capital. We obtain a positive and statistically 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 (see Table A5 in the Appendix).

Table 6
Headquarter intensity and the export share of vertically integrated plants (HS6-country level).

Trade regime	Import-assembly				Pure-assembly			
	OLS		Tobit		OLS		Tobit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity, ln(H/L)	0.101***		0.292***		−0.020		0.053***	
	(3.819)		(3.662)		(−0.718)		(2.620)	
Capital intensity, ln(K/L)	0.149***	0.100***	0.238***	0.166***	−0.128***	−0.078	−0.321***	−0.225***
	(4.323)	(2.760)	(4.596)	(2.954)	(−2.722)	(−1.499)	(−33.483)	(−22.444)
R&D intensity, ln(RD/Q)		0.112***		0.079***		−0.087***		−0.069***
		(3.702)		(3.635)		(−3.157)		(−15.512)
Material intensity, ln(M/L)	−0.107***	−0.096***	−0.207***	−0.191***	0.022	−0.002	0.050***	−0.007
	(−3.405)	(−2.997)	(−3.812)	(−3.491)	(0.778)	(−0.055)	(3.169)	(−0.436)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	80,474	77,181	80,474	77,181	80,474	77,181	80,474	77,181
No. clusters	349	318	349	318	349	318	349	318
R^2	.04	.039	.019	.019	.043	.045	.079	.08
N left-censored			18,203	17,406			64,798	62,683
N right-censored			28,857	27,968			2295	2143

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country. Standardized beta coefficients are reported for OLS results. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*** $p<0.01$.

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 also focus on Chinese exports to developed countries. We conduct regression analyses over groups of countries at different levels of development (low-income countries, high-income countries, and a few selected countries). The results from OLS are reported in Table 7.[38] Columns (1) through (6) show results for import-assembly, while those for pure-assembly are reported in columns (7) to (12). Results are largely consistent with those reported in Table 5 for the full sample of countries.

To address the concern that the US-based factor intensity measures may not reflect the intrinsic properties of production, and are specific to the U.S., we focus on Chinese exports to the U.S. only in column (3). The results are quantitatively similar to those for the full sample reported in Table 5, in terms of sign, magnitude and statistical significance. Columns (4) and (5) report consistent results using the samples of exports to Japan and to high-income European countries, respectively. In column (6) we exclude exports to Hong Kong from the sample 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 consistent with those when the full sample of countries is used, in sign, statistical significance and magnitude.

In sum, the results reported in this section show that while for the import-assembly regime the share of vertical integration is positively and significantly correlated with the intensity of inputs provided by the headquarter, for the pure-assembly regime there is no evidence of a positive relationship. These results are consistent with our theoretical Prediction 1, which predicts that if the benefit to integrate is significantly larger for the headquarter when she does not control any imported inputs (import-assembly) than when she does (pure-assembly), the share of vertically-integrated exports under import-assembly is increasing in the sector's headquarter intensity, whereas that under pure-assembly is decreasing.

5.2. Examining the effects of productivity dispersion

This section investigates the effect of 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.[39] Our model predicts that when the distribution of firm productivity becomes more dispersed (i.e., more clustered on the right tail), the share of integrated plants' exports under pure-assembly increases while the relationship is ambiguous in the import-assembly regime.[40]

We follow Helpman et al. (2004) and use the standard deviation of the log of firm sales across firms within an industry (σ_j^θ) as the empirical counterpart of productivity dispersion. We estimate the following equation:

$$\left(\frac{X_{lV}}{\sum_{l=N,S;k=V,O} X_{lk}}\right)_{pjc} = d_c + \left(\delta_\theta + \delta_{\theta\eta}\eta_j\right) \times \sigma_j^\theta + \gamma_h \Gamma_j + \epsilon_{pjc} \tag{11}$$

where l is the regime type (import-assembly or pure assembly) and Γ_j contains the headquarter intensity measures defined above. η_j is one of the measures of headquarter intensity (skill, capital or R&D). We control for importer heterogeneity by including country fixed effects, d_c. The model predicts that the most productive firms engage in integration under pure-assembly in headquarter-intensive sectors. Thus, we expect $\delta_\theta > 0$ and $\delta_{\theta\eta} > 0$ for the pure-assembly regime.

Using the product-country sample, we report the estimates of Eq. (11) in Table 8. We include all stand-alone headquarter intensity measures as controls, and cluster standard errors at the SIC 4-digit level. Columns (1) to (3) report results for the pure-assembly regime. The coefficients on both the stand-alone productivity dispersion term σ_j^θ and productivity dispersion interacted with headquarter intensity $\eta_j \times \sigma_j^\theta$ are positive and statistically significant at 1% level, for all proxies of headquarter inputs, η_j, used. This suggests that the export share of integrated plants increases in productivity dispersion in sectors with higher headquarter intensity. For import-assembly, we do not find evidence of a positive relationship between sectoral productivity

[38] Results are robust to using Tobit methods, and to including the measures of equipment-capital and plant-capital separately in alternative to the overall measure of physical capital. Results remain robust when we include R&D intensity as an alternative proxy for headquarter intensity.

[39] According to Bernard et al. (2007) and Bernard et al. (2009), the top 1 (10) percent of the U.S. trading firms accounted for 81 (96) percent of U.S. trade in 2000.

[40] The ambiguity arises because both organization modes could lose market share when the distribution of firm productivity is more dispersed.

Table 7
Headquarter intensity and the export share of vertically integrated plants (different country groups) (HS6 level).

Country group	Import-assembly						Pure-assembly					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	LIC	HIC	USA	JAPAN	EUROPE_HIC	EXCLUDE HK	LIC	HIC	USA	JAPAN	EUROPE_HIC	EXCLUDE HK
Skill intensity, ln(H/L)	0.134***	0.075**	0.071**	0.085***	0.111***	0.089**	−0.060	−0.027	−0.028	−0.058	−0.055*	-0.028
	(3.731)	(2.511)	(2.258)	(2.614)	(3.166)	(2.410)	(−1.419)	(−0.682)	(−0.883)	(−1.291)	(−1.790)	(−0.664)
Capital intensity, ln(K/L)	0.189***	0.148***	0.188***	0.234***	0.127***	0.171***	−0.064	−0.148**	−0.182***	−0.226***	−0.126***	−0.155**
	(3.779)	(2.906)	(4.410)	(4.570)	(3.064)	(3.374)	(−0.910)	(−2.223)	(−3.352)	(−3.019)	(−2.770)	(−2.228)
Material intensity, ln(M/L)	−0.130***	−0.119***	−0.169***	−0.106**	−0.137***	−0.132***	0.006	0.028	0.066	0.058	0.036	0.020
	(−2.946)	(−2.817)	(−3.974)	(−2.543)	(−3.667)	(−3.059)	(0.136)	(0.626)	(1.632)	(1.222)	(0.979)	(0.451)
N	1491	3585	2460	2721	2560	3525	1491	3585	2460	2721	2560	3525
No. clusters	282	346	321	331	323	347	282	346	321	331	323	347
No. countries	47	59	1	1	38	233	47	59	1	1	38	233
R^2	.044	.022	.034	.044	.03	.029	.0071	.018	.024	.042	.015	.021

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing 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 8
Productivity dispersion and the export share of vertically integrated plants (Chinese firms-sales-based dispersion measure) (HS6-country level).

	Chinese firms-sales-based dispersion measure					
Trade regime	Pure-assembly			Import-assembly		
Headquarter intensity measure	Skill	Capital	R&D	Skill	Capital	R&D
	(1)	(2)	(3)	(4)	(5)	(6)
Dispersion	0.133***	0.337***	0.241***	0.206***	−0.374**	−0.061
	(3.433)	(3.881)	(2.598)	(2.857)	(−2.466)	(−0.312)
Dispersion interaction	0.153***	0.202***	0.063***	0.148	−0.275***	−0.038
	(3.329)	(4.062)	(2.797)	(1.470)	(−3.292)	(−0.864)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Headquarter intensity controls	Yes	Yes	Yes	Yes	Yes	Yes
N	67,952	67,952	67,952	67,952	67,952	67,952
No. clusters	286	286	286	286	286	286
R^2	.051	.057	.051	.047	.05	.046

Dependent variable: China's foreign-affiliated plants' Export Processing exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country. Regular 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(K/L), ln(RD/Q) and ln(M/L).
** $p<0.05$.
*** $p<0.01$.

dispersion and the share of integrated plants' exports (columns (4) to (6)). These results provide support for prediction 2.

For robustness checks, we also use exports-based measures of productivity dispersion, following Nunn and Trefler (2008). Results are reported in Table 9. In columns (1) through (6), the measure of productivity dispersion used is the standard deviation of the log of export revenue of Chinese export processing plants in each sector in 2005. The results are largely consistent with those from Table 8. All dispersion and interaction terms are positive and statistically significant for pure-assembly, while they are insignificant for import-assembly. We obtain similar results when using the U.S. export-based measure of productivity dispersion from Nunn and Trefler (2008), with the exception that when skill is used to proxy for η_j the coefficients in column (7) become insignificant. All the results in this section are robust to using a sample at the HS 6-digit product level.

5.3. Robustness checks

In this section, we present robustness checks for the baseline results from Section 5.1. The factor intensity measures we used previously are constructed using the U.S. data, which is 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,[41] to check the robustness of our results we also use factor intensity and R&D intensity measures constructed using the Chinese firm-level data. The Chinese measures are described in Section 4. Table 10 reports results at the HS6-country level. We obtain a positive and statistically significant relationship between skill intensity, R&D and advertisement intensity, and the share of integrated plants' exports under import-assembly (columns (1) through (5)). The results are independent of using samples at the product or country-product level.

The coefficient on capital intensity is statistically insignificant. As discussed above, the overall physical capital measure includes

[41] 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 (2007) and Manova (2007), among others.

Table 9
Productivity dispersion and the export share of vertically integrated plants (export-based dispersion measure) (HS6-country level).

	Chinese firms-export-based dispersion measure						US firms-export-based dispersion measure					
Trade regime	Pure-assembly			Import-assembly			Pure-assembly			Import-assembly		
Headquarter intensity measure	Skill	Capital	R&D	Skill	Capital	R&D	Skill	Capital	R&D	Skill	Capital	R&D
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dispersion	0.032*	0.077***	0.066***	0.050	0.077	0.070	0.074	0.188***	0.130**	0.090	−0.262***	−0.032
	(1.691)	(3.970)	(2.597)	(1.079)	(1.421)	(1.271)	(1.543)	(3.686)	(2.398)	(1.164)	(−3.497)	(−0.326)
Dispersion interaction	0.037*	0.045***	0.016***	−0.074	−0.023	−0.011	0.060	0.094***	0.026**	0.054	−0.165***	−0.016
	(1.932)	(4.006)	(2.674)	(−1.559)	(−0.784)	(−0.941)	(1.236)	(3.700)	(2.249)	(0.685)	(−4.475)	(−0.811)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Headquarter intensity controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	76,611	76,611	76,611	76,611	76,611	76,611	77,111	77,111	77,111	77,111	77,111	77,111
No. clusters	310	310	310	310	310	310	316	316	316	316	316	316
R^2	.046	.049	.048	.064	.063	.063	.046	.052	.048	.045	.05	.045

Dependent variable: China's foreign-affiliated plants' Export Processing exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country. Regular 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(K/L), ln(RD/Q) and ln(M/L).
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

Table 10
Headquarter intensity and the export share of vertically integrated plants (using Chinese data to measure factor intensities) (HS6-country level).

Trade regime	Import-assembly					Pure-assembly				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Skill Int.	0.172***			0.185***		−0.155***			−0.135***	
	(6.961)			(7.691)		(−5.915)			(−5.171)	
R&D + Adv. Int.		0.127***			0.127***		−0.078***			−0.078***
		(5.143)			(5.139)		(−2.861)			(−2.910)
Capital Int.			0.016	−0.040	0.045			−0.106***	−0.065**	−0.127***
			(0.467)	(−1.460)	(1.309)			(−3.112)	(−1.995)	(−3.840)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	80,528	71,116	80,528	80,528	71,116	80,528	71,116	80,528	80,528	71,116
No. clusters	351	314	351	351	314	351	314	351	351	314
R^2	.041	.029	.012	.043	.031	.052	.035	.04	.056	.051

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country. 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.
** $p<0.05$.
*** $p<0.01$.

investments that are easily contractible and therefore not relevant for the integration decision. However, the Chinese data limit us from constructing measures of contractible and non-contractible investments in capital separately in the regressions. For pure-assembly, we find evidence of a negative relationship between the measures of headquarter intensity and the share of vertically integrated exports (columns (6) through (10)). These findings are largely consistent with the results obtained when we use the US-based measures of factor intensity.

The vertically-integrated export shares are bounded between the values zero and one. Table A1 shows that there are a number of observations that cluster around the two endpoints. It is expected that in thinner markers there will be more clustering around zero and one. For example, in the extreme situation where there is only one firm in a HS 6-digit category, the firm will either vertically integrate with the plant or offshore. To take this into account, as a further robustness check we limit the estimation sample to larger HS6 sectors which are more likely to be populated by a large number of firms with different productivity levels that chose different production modes. We estimate Eq. (10) including only large HS6 categories by dropping the bottom 3 deciles in terms of export volume.[42] Table 11 reports the regression results. We continue to find that the share of vertical integrated exports is positively and significantly correlated with all measures of headquarters intensity of inputs for import-assembly. The coefficients are also of similar magnitude to those reported in Table 6. The results are robust to using observations at the product or product-country level. For pure-assembly, we find no evidence of a positive correlation between headquarter intensity and vertical integration.

As a further robustness check, instead of running separate regressions for the import-assembly and pure-assembly regimes we pool the data across the two regimes and run a regression on the full sample including dummies for import-assembly. Results from OLS are reported in Table 12.[43] Columns (1) through (4) report results at the HS6 level while columns (5) through (8) report those for the

[42] We also performed similar exercises dropping the lowest 10%, 20% or 40% of HS6 sectors by export value, and obtained quantitatively similar results in sign, magnitude and statistical significance.
[43] Results are robust to using Tobit methods.

Table 11
Headquarter intensity and the export share of vertically integrated plants (HS6-country level) (large HS6 sample).

Trade regime	Import-assembly				Pure-assembly			
	OLS		Tobit		OLS		Tobit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity, ln(H/L)	0.100***		0.282***		−0.012		0.080***	
	(3.716)		(3.555)		(−0.434)		(4.058)	
Capital intensity, ln(K/L)	0.153***	0.104***	0.239***	0.168***	−0.131***	−0.081	−0.316***	−0.221***
	(4.387)	(2.854)	(4.649)	(3.053)	(−2.825)	(−1.580)	(−34.104)	(−22.694)
R&D intensity, ln(RD/Q)		0.110***		0.076***		−0.084***		−0.065***
		(3.591)		(3.516)		(−3.076)		(−14.882)
Material intensity, ln(M/L)	−0.110***	−0.100***	−0.210***	−0.194***	0.023	−0.001	0.051***	−0.004
	(−3.440)	(−3.047)	(−3.850)	(−3.541)	(0.824)	(−0.018)	(3.369)	(−0.288)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	77,814	74,617	77,814	74,617	77,814	74,617	77,814	74,617
No. clusters	340	310	340	310	340	310	340	310
R^2	.041	.04	.02	.019	.042	.044	.082	.082
N left-censored			17,197	16,442			62,514	60,468
N right-censored			27,570	26,719			2086	1947

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing exports. The estimation sample for this table is restricted to the largest HS6 categories in export value, by dropping the bottom 3 deciles. An observation is a 6-digit HS product category to each country. Standardized beta coefficients are reported for OLS results. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
*** $p<0.01$.

HS6-country level. We include the measures of headquarter intensity as well as interaction terms between the headquarter intensity proxies and a dummy variable which takes the value of one for the import-assembly regime. The table reports regular, unstandardized coefficients, for direct comparison with those that result from running separate regressions for each regime.

Table 12
Headquarter intensity and the export share of vertically integrated plants, pooled across regimes, dummy for import-assembly.

Trade regime	HS6				HS6-country			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D∗Skill intensity	0.101**		0.192***		0.153***		0.249***	
	(2.100)		(4.415)		(3.329)		(5.964)	
D∗Capital intensity	0.128***	0.085*			0.158***	0.103**		
	(2.637)	(1.734)			(3.917)	(2.353)		
D∗R&D intensity		0.052***		0.061***		0.053***		0.063***
		(3.881)		(5.040)		(3.913)		(5.202)
D∗Equipment intensity			0.216***	0.145***			0.228***	0.136***
			(4.090)	(2.838)			(5.787)	(3.324)
D∗Plant Intensity			−0.220***	−0.203***			−0.220***	−0.182***
			(−5.043)	(−4.753)			(−6.066)	(−5.198)
D∗Material intensity	−0.072**	−0.046	−0.016	0.018	−0.099***	−0.080**	−0.045	−0.020
	(−1.981)	(−1.312)	(−0.489)	(0.562)	(−2.887)	(−2.296)	(−1.446)	(−0.642)
Skill intensity	−0.014		−0.050**		−0.016		−0.045**	
	(−0.542)		(−2.315)		(−0.817)		(−2.496)	
Capital intensity	−0.045**	−0.023			−0.048***	−0.029		
	(−1.970)	(−1.043)			(−2.688)	(−1.450)		
R&D intensity		−0.021***		−0.022***		−0.015***		−0.017***
		(−3.500)		(−3.958)		(−3.168)		(−4.267)
Equipment intensity			−0.083***	−0.060**			−0.071***	−0.048**
			(−3.413)	(−2.420)			(−4.062)	(−2.552)
Plant intensity			0.066***	0.059***			0.063***	0.054***
			(2.974)	(2.738)			(4.675)	(4.175)
Material intensity	0.003	−0.013	−0.005	−0.017	0.010	0.000	−0.004	−0.011
	(0.205)	(−0.857)	(−0.339)	(−1.166)	(0.820)	(0.004)	(−0.325)	(−1.029)
Country fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
N	7328	7082	7328	7082	160,948	154,362	160,948	154,362
No. clusters	349	318	349	318	349	318	349	318
R^2	.39	.4	.4	.41	.39	.4	.4	.41

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category in columns (1) to (4) and a 6-digit HS product category to each country in columns (5) to (8). The estimation sample includes observations in both regimes, and D is a dummy variable for the import-assembly regime. t-stats based on standard errors clustered at the SIC4 level are in parentheses.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

The coefficients on the stand-alone headquarter intensity measures correspond to those for the pure-assembly regime.[44] They remain statistically insignificant or negative and significant. The coefficients on the interaction between headquarter intensity and the dummy for import-assembly correspond to the difference in the headquarter intensity coefficients between the two regimes. The results show that the difference is positive and statistically significant for all proxies of headquarter intensity. We therefore confirm the finding of a positive and significant correlation between the share of vertically integrated exports and all measures of headquarter intensity for the import-assembly regime but not for pure-assembly. Results show that the coefficients are statistically different between the two regimes. In sum, the results reported in this section confirm the findings from the baseline specifications reported in the previous sections.

6. Conclusions

This paper uses detailed product-level export data for China to investigate the determinants of foreign integration versus outsourcing. We exploit the coexistence of two regulatory trade regimes for export processing in China, pure-assembly and import-assembly, which let us observe the allocation of ownership and control rights over imported components in a multinational production relationship. Under import-assembly, Chinese plants make the decision of which components to purchase and have control rights over their use. Under pure-assembly, ownership and control over the components shipped to China remains with the final-good producer. To examine how choices of organizational structure are affected by the allocation of control rights over the imported inputs in export processing, we present an extension of the Antràs and Helpman (2004) model to consider investments in input purchasing.

By considering two ownership structures under two trade regimes, our model predicts that if the benefit to integrate is significantly larger for the headquarter when she does not control any imported inputs (import-assembly) than when she does (pure-assembly), the share of vertically-integrated exports under import-assembly is increasing in the sector's headquarter intensity, consistent with the main prediction in Antràs (2003); whereas that under pure-assembly is decreasing. In a headquarter-intensive sector where safeguarding the headquarter's investment incentives is important, a foreign client can choose to either own and control imported inputs or own only the plant's assets to alleviate hold-up. The export volume from integrated plants increases for both import-assembly and pure-assembly. If the export volume increases more for the former, the share of integrated plants under pure-assembly in total processing trade decreases.

Our empirical results show that when the control rights over the input-purchase decisions are allocated to the Chinese assembly plant, the export share of integrated plants is increasing in the intensity of headquarter inputs across sectors. These results are consistent with the existing research on intra-firm trade. However, if Chinese plants engage in pure-assembly (i.e., the foreign firm has ownership and control over the components shipped to China), we find no evidence of a positive correlation between the prevalence of vertical integration and the intensity of headquarter inputs, consistent with our model predictions. These results imply that control over components for assembly can be used as an alternative to asset ownership to mitigate hold-up by foreign suppliers when offshoring assembly tasks.

Consistent with the theoretical prediction about the sorting of firms into different production modes, we find that the export share of integrated plants in pure-assembly increases in productivity dispersion in sectors with higher headquarter intensity. For import-assembly, we do not find evidence of a positive relationship between sectoral productivity dispersion and the share of integrated plants' exports.

Appendix A

A.1. Derivation of the model

Pure-assembly (the N mode). Recall from the main text that under pure-assembly (the N mode), the ex-post revenue-sharing rules imply $\beta_{NV}=\delta^{\alpha}+\beta(1-\delta^{\alpha})>\beta_{NO}=\beta$. In this regime, H maximizes her expected operating profits anticipating ex post payoffs as follows:

$$\max_{m,h}\{\beta_{Nk}R(m,a,h)-w_N\lambda_N m-w_N h\}.$$

A's maximization problem is

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

For organizational form $k\in\{V,O\}$, solving H's and A's problems simultaneously gives the profit-maximizing levels a^*, h^* and m^* in terms of w_S, w_S, λ, θ, D, η's and importantly, β_{Nk}.[45] Plugging a^*, h^*, and m^* into the production unit's revenue function (Eq. (3)), we solve for firm revenue associated with organization mode k under pure-assembly as $R_{Nk}=D\Theta\varphi_{Nk}$, where $\Theta\equiv\theta^{\frac{\alpha}{1-\alpha}}$ and

$$\varphi_{Nk}=\left[\frac{(\lambda_N)^{\eta^m}}{\alpha}\left(\frac{w_S}{1-\beta_{Nk}}\right)^{\eta^a}\left(\frac{w_N}{\beta_{Nk}}\right)^{\eta^h+\eta^m}\right]^{-\frac{\alpha}{1-\alpha}};$$

and the operating profit becomes $\pi_{Nk}=D\Theta\psi_{Nk}-w_N f_{Nk}$,, where f_{Nk} is the fixed cost of production and

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

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

$$\beta_N^*(\eta^a)=\frac{(1-\alpha\eta^a)(1-\eta^a)-\sqrt{\eta^a(1-\alpha\eta^a)(1-\eta^a)(1-\alpha(1-\eta^a))}}{1-2\eta^a}.$$

Notice $\beta_{N'}^*(\eta^a)<0$. Given that $\eta^a=1-(\eta^h+\eta^m)$, $\beta_{N'}^*(\eta^h+\eta^m)>0$. These comparative statics will ultimately determine the optimal production mode.

A.1.1. Import-assembly

Recall from the main text that under import-assembly (the S mode), the ex-post revenue-sharing rules imply $\beta_{SV}=\beta(1-\gamma)+(1-\beta)\delta^{\alpha}>\beta_{SO}=\beta(1-\gamma)$. Notice that $\beta_{NV}>\beta_{SV}>\beta_{SO}$. If we further assume that asset ownership is sufficiently more effective in alleviating the hold-up by A, that is, $\delta^{\alpha}(1-\beta)>\gamma$, we have $\beta_{SV}=\beta(1-\gamma)+(1-\beta)\delta^{\alpha}>\beta=\beta_{NO}$.

Anticipating ex-post bargaining as investments are non-contractible, H maximizes her expected operating profits as:

$$\max_{h}\{\beta_{Sk}R(m,a,h)-w_N h\}.$$

[44] Note that in Table 12 we report regular coefficients while in Tables 5 and 6 we report standardized beta coefficients. The coefficients on the stand alone headquarter intensity measures reported in Table 12 are identical to the unstandardized coefficients corresponding to the results from Tables 5 and 6, for the pure-assembly regime. The unstandardized coefficients from the separate regression for import-assembly are identical to the sum of the coefficients on the stand-alone headquarter measures and the interaction terms reported in Table 12.

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

A's maximization problem is

$$\max_{a,m}\{(1-\beta_{Sk})R(m,a,h)-w_S\lambda_S m-w_S a\}$$

For organizational form $k\in\{V,O\}$, solving H's and A's problems simultaneously gives the profit-maximizing investment levels a^*, h^* and m^* in terms of w_S, w_N, λ, θ, D, η's and importantly, β_{Sk}.[46] Plugging a^*, h^* and m^* into the joint production unit's revenue (Eq. (3)), we obtain revenue for organization mode k under pure-assembly as $R_{Nk}=D\Theta\varphi_{Sk}$, where $\Theta\equiv\theta^{\frac{\alpha}{1-\alpha}}$ and

$$\varphi_{Sk}=\left[\frac{(\lambda_S)^{\eta^m}}{\alpha}\left(\frac{w_S}{1-\beta_{Sk}}\right)^{1-\eta^h}\left(\frac{w_N}{\beta_{Sk}}\right)^{\eta^h}\right]^{-\frac{\alpha}{1-\alpha}}.$$

The joint production unit's operating profit (which is H's objective when choosing the optimal production mode as we will see below) can be expressed as $\pi_{Sk}=\psi_{Sk}D\Theta-w^N f_{Sk}$, where $\Theta\equiv\theta^{\frac{\alpha}{1-\alpha}}$ and

$$\psi_{Sk}=\varphi_{Sk}\left\{1-\alpha\left[\beta_{Sk}\eta^h+(1-\beta_{Sk})\left(1-\eta^h\right)\right]\right\}.$$

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

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

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

A.1.2. Choosing Optimal Production Modes

The coexistence of all four production modes, as illustrated in Fig. 1, requires a specific ranking of ψ'_{lk}s. The ranking of ψ'_{lk}s ultimately depends on β'_{Sk}s and the input prices: w_N, w_S, λ_N, and λ_S. On the one hand, for a given organizational mode (k), giving H's control over imported components under pure assembly gives her more incentives to invest in headquarter activities compared with import-assembly (i.e., $\psi_{Sk}<\psi_{Nk}$). On the other hand, lower w_S can make A's procurement of components and thus import-assembly more attractive than pure-assembly for H. Formally, for a given component intensity η^m, outsourcing under pure-assembly would be more profitable than integration under import-assembly (i.e., $\psi_{NO}>\psi_{SV}$) if and only if

$$\left(\frac{\lambda_N}{\lambda_S}\right)^{\eta^m}\le\frac{\nu\left(\beta_{NO},\eta^h\right)}{\zeta\left(\beta_{SV},\eta^h\right)},\tag{12}$$

where $\nu\left(\xi,\eta^h\right)=\left[1-\alpha\left(\xi\eta^h+\xi\eta^m+(1-\xi)\left(1-\eta^h-\eta^m\right)\right)\right]^{\frac{1-\alpha}{\alpha}}\xi^{\eta^h+\eta^m}(1-\xi)^{1-\eta^h-\eta^m}$ and $\zeta\left(\xi,\eta^h\right)=\left[1-\alpha\left(\xi\eta^h+(1-\xi)\left(1-\eta^h\right)\right)\right]^{\frac{1-\alpha}{\alpha}}(1-\xi)^{1-\eta^h}\xi^{\eta^h}$.[47] The higher the marginal costs of component search in the North relative to the South, the more likely inequality (12) will hold.[48] As such, we have the following ranking of profitability (the slopes of π_{lk}):

$$\psi_{NV}>\psi_{NO}>\psi_{SV}>\psi_{SO}.$$

Proof of lemma. For organization mode k, $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}\ge0$.

Proof. Notice that $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}=\frac{\alpha}{1-\alpha}\ln\left(\frac{1-\beta_{Sk}}{1-\beta_{Nk}}\frac{\beta_{Nk}}{\beta_{Sk}}\right)+\left[\frac{\alpha(2\beta_{Sk}-1)}{\Omega_{Sk}\left(\eta^a,\eta^h\right)}-\frac{\alpha(2\beta_{Nk}-1)}{\Omega_{Nk}\left(\eta^a,\eta^h\right)}\right]$ where $\Omega_{Sk}(\eta^a,\eta^h)=1-\alpha[\beta_{Sk}\eta^h+(1-\beta_{Sk})(1-\eta^h)]$ and $\Omega_{Nk}(\eta^a,\eta^h)=1-\alpha[\beta_{Nk}(\eta^m+\eta^h)+(1-\beta_{Nk})(1-\eta^h-\eta^m)]$.[49]

Consider $\eta^h=1$ (i.e., $\eta^a=\eta^m=0$) for the moment. $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}=\frac{\alpha}{1-\alpha}\ln\left(\frac{1-\beta_{Sk}}{1-\beta_{Nk}}\frac{\beta_{Nk}}{\beta_{Sk}}\right)+\left[\frac{\alpha(2\beta_{Sk}-1)}{1-\alpha\beta_{Sk}}-\frac{\alpha(2\beta_{Nk}-1)}{1-\alpha\beta_{Nk}}\right]$. Notice that $\frac{d}{d\gamma}\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}=\beta\left[\frac{\alpha}{1-\alpha}\left(\frac{1}{(1-\beta_{Sk})\beta_{Sk}}\right)-\frac{\alpha(2-\alpha)}{(1-\alpha\beta_{Sk})^2}\right]$. Given that $(1-\beta_{Sk})(1-\alpha)\beta_{Sk}<(1-\alpha\beta_{Sk})^2$, we know that $\frac{d}{d\gamma}\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}>0$. Since when $\gamma=0$, $\psi_{Nk}=\psi_{Sk}$ and $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}=0$ for $k=\{O,V\}$, we can show that $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}>0\,\forall\gamma\in[0,1]$.

Let us know consider $\eta^h<1$. Notice that $\frac{d\Omega_{Sk}\left(\eta^a,\eta^h\right)}{d\eta^h}=-\alpha(2\beta_{Sk}-1)>\frac{d\Omega_{Nk}\left(\eta^a,\eta^h\right)}{d\eta^h}=-\alpha(2\beta_{Nk}-1)$, together with $\beta_{Nk}>\beta_{Sk}$, we can show that $\frac{d^2\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{\left(d\eta^h\right)^2}<0$. Since $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}>0$ when $\eta^h=1$, $\frac{d\left(\ln\frac{\psi_{Nk}}{\psi_{Sk}}\right)}{d\eta^h}\ge0\ \forall\eta^h\in[0,1]$. ■

Similarly, we can show that $\frac{d\left(\ln\frac{\psi_{lV}}{\psi_{lO}}\right)}{d\eta^h}\ge0$ for trade regime l; and since we assume that asset ownership is more effective in alleviating hold-up compared to input control (i.e., $\beta_{SV}>\beta_{NO}$), we can show that $\frac{d\left(\ln\frac{\psi_{NO}}{\psi_{SV}}\right)}{d\eta^h}\le0$.

The export share of integrated import-assembly processing plants in total processing exports is

$$s_{SV}=\frac{X_{SV}}{\sum_{l=V,O;k=N,S}X_{lk}}=\left[\frac{X_{SO}}{X_{SV}}+\frac{X_{NO}}{X_{SV}}+\frac{X_{NV}}{X_{SV}}+1\right]^{-1},$$

where $\frac{X_{SO}}{X_{SV}}=\frac{\varphi_{SO}}{\varphi_{SV}}\left[\left(\frac{\Theta_{SV}}{\Theta_{SO}}\right)^{\kappa-1}-1\right]\left[1-\left(\frac{\Theta_{SV}}{\Theta_{NO}}\right)^{\kappa-1}\right]^{-1}$; $\frac{X_{NO}}{X_{SV}}=\frac{\varphi_{NO}}{\varphi_{SV}}\left[1-\left(\frac{\Theta_{NO}}{\Theta_{NV}}\right)^{\kappa-1}\right]\left[\left(\frac{\Theta_{NO}}{\Theta_{SV}}\right)^{\kappa-1}-1\right]^{-1}$; and $\frac{X_{NV}}{X_{SV}}=\frac{\varphi_{NV}}{\varphi_{SV}}\left[\left(\frac{\Theta_{NV}}{\Theta_{SV}}\right)^{\kappa-1}-\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)^{\kappa-1}\right]^{-1}$. Simple comparative statics show that both $\frac{X_{SO}}{X_{SV}}$ and $\frac{X_{NO}}{X_{SV}}$ are decreasing in η^h. The impact of an increase of η^h on $\frac{X_{NV}}{X_{SV}}$ is ambiguous since $\frac{\varphi_{NV}}{\varphi_{SV}}$ is increasing in η^h, but $\frac{\Theta_{NV}}{\Theta_{NO}}$ is increasing in η^h whereas $\frac{\Theta_{NV}}{\Theta_{SV}}$ can be increasing or decreasing in η^h. As such, the relation between η^h and $\frac{X_{SV}}{\sum_{l=V,O;k=N,S}X_{lk}}$ is ambiguous. See Fig. 2 for a graphical exposition.

The export share of integrated pure-assembly plants in total processing exports is

$$s_{NV}=\frac{X_{NV}}{\sum_{l=V,O;k=N,S}X_{lk}}=\left[\frac{X_{SO}}{X_{NV}}+\frac{X_{NO}}{X_{NV}}+\frac{X_{SV}}{X_{NV}}+1\right]^{-1},$$

where $\frac{X_{SO}}{X_{NV}}=\frac{\varphi_{SO}}{\varphi_{NV}}\left(\frac{\Theta_{NV}}{\Theta_{SO}}\right)^{\kappa-1}\left[1-\left(\frac{\Theta_{SO}}{\Theta_{SV}}\right)^{\kappa-1}\right]$; $\frac{X_{NO}}{X_{NV}}=\frac{\varphi_{NO}}{\varphi_{NV}}\left[\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)^{\kappa-1}-1\right]$; and $\frac{X_{SV}}{X_{NV}}=\frac{\varphi_{SV}}{\varphi_{NV}}\left[\left(\frac{\Theta_{NV}}{\Theta_{SV}}\right)^{\kappa-1}-\left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)^{\kappa-1}\right]$. Simple comparative statics show that both $\frac{X_{SO}}{X_{NV}}$ and $\frac{X_{NO}}{X_{NV}}$ are decreasing in η^h. As is discussed above, the impact of an increase of η^h on $\frac{X_{NV}}{X_{SV}}$ is ambiguous, implying that the relation between η^h and $\frac{X_{NV}}{\sum_{l=V,O;k=N,S}X_{lk}}$ is also ambiguous.

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

[47] We obtain this inequality by rearranging $\psi_{NO}(\beta_{NO},\eta^a,\eta^h)>\psi_{SV}(\beta_{SV},\eta^a,\eta^h)$.

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

[49] $\frac{\Omega_{Sk}(0)}{\Omega_{Nk}(0)}=\frac{1-\alpha(1-\beta_{Sk})}{1-\alpha[\beta_{Nk}-(2\beta_{Nk}-1)\eta^a]}$ and $\frac{\Omega_{Sk}(1)}{\Omega_{Nk}(1)}=\frac{1-\alpha\beta_{Sk}}{1-\alpha\beta_{Nk}}$. While the value of $\frac{\Omega_{Sk}(0)}{\Omega_{Nk}(0)}$ depends on the value of η^a, $\frac{\Omega_{Sk}(1)}{\Omega_{Nk}(1)}>1>\frac{2\beta_{Sk}-1}{2\beta_{Nk}-1}$.

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	0.197	0.615	0.900	1	0.552	3825
Pure-assembly	0	0	0.002	0.091	0.365	0.106	3825

Table A2
Summary statistics of headquarter intensity measures (across SIC 4-digit categories).

	10th	25th	50th	75th	90th	mean	# of SIC
Skill intensity, ln(H/L)	−1.330	−1.165	−0.973	−0.757	−0.557	−0.966	451
Capital intensity, ln(K/L)	−2.655	−2.272	−1.922	−1.458	−0.978	−1.862	451
R&D intensity, ln (RD/Q)	−6.269	−5.331	−4.474	−3.677	−3.012	−4.585	414
Material intensity, ln (M/L)	0.378	0.665	1.025	1.423	1.904	1.092	451
Equipment intensity, ln (E/L)	−0.374	−0.015	0.425	0.910	1.465	0.487	451
Structure intensity, ln(P/L)	−0.717	−0.471	−0.128	0.339	0.789	−0.034	451
ln(high-sch emp/emp), Chinese plants, ln(H/E)	−1.179	−1.031	−0.797	−0.618	−0.418	−0.811	513
ln(college em/emp), Chinese plants, ln(C/E)	−3.069	−2.669	−2.273	−1.819	−1.437	−2.250	513
ln(real value K/real Y), Chinese plants, ln(K/Y)	−1.336	−1.082	−0.814	−0.563	−0.086	−0.768	513
ln(R&D + Advert. Intensity), Chinese Plants, ln(RD/V)	−7.051	−6.575	−5.949	−5.246	−4.493	−5.857	458

Table A3
Correlations between headquarter intensity measures (across SIC 4-digit).

	ln(H/L)	ln(K/L)	ln(RD/Q)	ln(M/L)	ln(E/L)	ln(P/L)	ln(H/E)	ln(C/E)	ln(K/Y)	ln(RD/V)
ln(H/L)	1.000									
ln(K/L)	−0.141	1.000								
ln (RD/Q)	0.475	0.051	1.000							
ln(M/L)	−0.232	0.628	−0.196	1.000						
ln(E/L)	−0.257	0.774	−0.003	0.545	1.000					
ln(P/L)	−0.068	0.585	0.041	0.530	0.782	1.000				
ln(H/E)	0.429	0.258	0.429	0.120	0.186	0.177	1.000			
ln(C/E)	0.474	0.209	0.443	0.072	0.111	0.108	0.968	1.000		
ln(K/Y)	−0.065	0.256	0.099	−0.058	0.289	0.247	0.308	0.280	1.000	
ln(RD/V)	0.413	0.024	0.425	−0.067	−0.116	0.002	0.519	0.562	0.084	1.000

Despite the ambiguous results, the share of total integrated exports ($s_{SV}+s_{NV}$) is increasing in η^h since $\frac{X_{SO}}{X_{SV}}$, $\frac{X_{NO}}{X_{SV}}$, $\frac{X_{SO}}{X_{NV}}$, and $\frac{X_{NO}}{X_{NV}}$ are all decreasing in η^h. This result implies that either s_{SV}, s_{NV}, or both need to be increasing in η^h. Of note, the ratio $\frac{X_{SV}}{X_{NV}}$, which appears in both (7) and (8), plays a key role in determining the relation between η^h, s_{NV}, and s_{SV}. Specifically, if $\frac{d\left(\frac{X_{SV}}{X_{NV}}\right)}{d\eta^h} > -\frac{d\left(\frac{X_{SO}}{X_{NV}}+\frac{X_{NO}}{X_{NV}}\right)}{d\eta^h} > 0$, $\frac{ds_{SV}}{d\eta^h} > 0$ but $\frac{ds_{NV}}{d\eta^h} < 0$.[50] Recall that $\frac{X_{SV}}{X_{NV}} = \frac{\varphi_{SV}}{\varphi_{NV}}\left[\left(\frac{\Theta_{NV}}{\Theta_{SV}}\right)^{\kappa-1} - \left(\frac{\Theta_{NV}}{\Theta_{NO}}\right)^{\kappa-1}\right]$. Fig. 2 shows that the productivity cutoffs Θ_{NV} and Θ_{SV} are both decreasing in η^h. Figuratively, a sufficiently high $\frac{d\left(\frac{X_{SV}}{X_{NV}}\right)}{d\eta^h}$ requires Θ_{NV} declines sufficiently less than Θ_{SV} (i.e., $\frac{d\left(\frac{\Theta_{NV}}{\Theta_{SV}}\right)}{d\eta^h}$ is sufficiently positive). Formally, a sufficiently high $\frac{d\ln\frac{\Theta_{NV}}{\Theta_{SV}}}{d\eta^h}$ require that

$$\frac{d\left(\frac{\psi_{SV}}{\psi_{SO}}\right)}{d\eta^h} >> \frac{\left(\frac{\psi_{SV}}{\psi_{SO}}-1\right)}{\left(\frac{\psi_{NV}}{\psi_{NO}}-1\right)}\frac{d\left(\frac{\psi_{NV}}{\psi_{NO}}\right)}{d\eta^h} + \left(\frac{\psi_{SV}}{\psi_{NO}}-\frac{\psi_{SO}}{\psi_{NO}}\right)\frac{d\left(\frac{\psi_{NO}}{\psi_{SO}}\right)}{d\eta^h} > 0. \tag{13}$$

If inequality (13) holds with a wide margin, the integrated export share under import-assembly would increase with η^h, whereas that under pure-assembly would decrease. The required inequality is more likely to satisfy if integration is associated with a substantially smaller increase in profitability with controls over inputs rather than without (i.e., a high $\frac{d\left(\frac{\psi_{SV}}{\psi_{SO}}\right)}{d\eta^h}$). Consistently, if ψ_{SV}/ψ_{SO} to 1, compared to ψ_{NV}/ψ_{NO} (i.e., integration does not buy H that much benefit if inputs are controlled by A), the required inequality is also more likely to hold. These results are summarized in Prediction 1.

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

Using (8), and that $\frac{\Theta_{NV}}{\Theta_{SO}} > \frac{\Theta_{NV}}{\Theta_{SV}} > \frac{\Theta_{NV}}{\Theta_{NO}} > 1$ and $\frac{\Theta_{SV}}{\Theta_{SO}} > 1$, it can be shown that $\frac{ds_{NV}}{d\kappa}<0$ (i.e., s_{NV} is increasing with the variance of Θ).

Using (7), the sign of $\frac{ds_{SV}}{d\kappa}$ is generally indeterminate.

A.2. Data Appendix

The concordance file for mapping SIC87 (4-digit) codes to HS-6 digit codes is taken from Peter Schott's website. We use the new concordance of 1989-2008 US HS codes to US SIC, SITC and NAICS codes over time, based on exports.[51] When more than one SIC code is identified for a HS6 code (it happens for 371 HS6 codes out of 5203 in manufacturing industries), the SIC code that covers the most HS8 categories within the HS6 code is used. For some cases, a HS6 code has multiple SIC codes tied in the number of HS8 categories shared (it happens for 208 cases). In those situations, we choose the SIC category that has the highest number of HS6 categories under it as the unique map (Tables A2, A3).

[50] Notice that $\frac{d\left(\frac{X_{SV}}{X_{NV}}\right)}{d\eta^h} > 0$ implies that $\frac{d\left(\frac{X_{NV}}{X_{SV}}\right)}{d\eta^h} < 0$ and thus s_{SV} is increasing in η^h unambiguously.

[51] http://www.som.yale.edu/faculty/pks4/sub_international.htm.

Table A4
Headquarter intensity and the export share of vertically integrated plants.

	HS6-country				HS6			
	OLS		Tobit		OLS		Tobit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity, ln(H/L)	0.123***		0.345***		0.091***		0.108***	
	(4.585)		(4.266)		(2.830)		(2.753)	
R&D intensity, ln(RD/Q)		0.088***		0.062***		0.062**		0.020**
		(3.335)		(3.109)		(2.244)		(2.113)
Equipment Intensity, ln(E/L)	0.139***	0.063**	0.224***	0.123***	0.105**	0.052	0.065**	0.035
	(4.471)	(1.992)	(5.331)	(2.762)	(2.028)	(0.969)	(2.193)	(1.073)
Plant intensity, ln(P/L)	−0.124***	−0.099***	−0.206***	−0.166***	−0.152***	−0.146**	−0.097**	−0.094**
	(−3.587)	(−2.829)	(−3.464)	(−2.775)	(−2.680)	(−2.543)	(−2.428)	(−2.288)
Material intensity, ln(M/L)	−0.066**	−0.053	−0.151***	−0.129**	−0.044	−0.029	−0.027	−0.017
	(−2.221)	(−1.625)	(−2.813)	(−2.196)	(−1.072)	(−0.707)	(−0.941)	(−0.573)
Country fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
N	80,474	77,181	80,474	77,181	3664	3541	3664	3541
No. clusters	349	318	349	318	349	318	349	318
R2	.038	.033	.018	.016	.021	.02	.01	.0091
N left-censored			14,899	14,358			319	314
N right-censored			33,454	32,285			570	560

Dependent variable: China's foreign-affiliated plants' Export Processing exports as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country in columns (1) to (4) and a 6-digit HS product category in columns (5) to (8). Standardized beta coefficients are reported for OLS results. t-stats based on standard errors clustered at the SIC4 level are in parentheses. ** p<0.05, *** p<0.01.

Table A5
Headquarter intensity and the export share of vertically integrated plants (HS6-country level).

Trade regime	Import-assembly				Pure-assembly			
	OLS		Tobit		OLS		Tobit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Skill intensity, ln(H/L)	0.151***		0.428***		−0.064**		−0.137***	
	(6.068)		(5.894)		(−2.437)		(−6.931)	
R&D intensity, ln(RD/Q)		0.134***		0.095***		−0.100***		−0.079***
		(4.777)		(4.579)		(−4.251)		(−19.767)
Equipment intensity, ln(E/L)	0.242***	0.135***	0.331***	0.188***	−0.214***	−0.149***	−0.444***	−0.355***
	(6.177)	(3.457)	(6.703)	(3.590)	(−4.103)	(−2.633)	(−24.316)	(−19.532)
Plant intensity, ln(P/L)	−0.198***	−0.162***	−0.314***	−0.257***	0.155***	0.134***	0.361***	0.333***
	(−5.512)	(−4.580)	(−5.258)	(−4.321)	(4.649)	(4.187)	(31.045)	(27.242)
Material intensity, ln(M/L)	−0.059**	−0.038	−0.128**	−0.092	−0.008	−0.027	−0.016	−0.053***
	(−1.975)	(−1.209)	(−2.377)	(−1.641)	(−0.307)	(−1.009)	(−0.905)	(−2.922)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	80,474	77,181	80,474	77,181	80,474	77,181	80,474	77,181
No. clusters	349	318	349	318	349	318	349	318
R^2	.049	.046	.022	.021	.049	.052	.088	.091
N left-censored			18,203	17,406			64,798	62,683
N right-censored			28,857	27,968			2295	2143

Dependent variable: China's foreign-affiliated plants' exports in each regime as a share of total Export Processing exports. An observation is a 6-digit HS product category to each country. Standardized beta coefficients are reported for OLS results. t-stats based on standard errors clustered at the SIC4 level are in parentheses. *p<0.10, ** p<0.05, *** p<0.01.

References

Aghion, P., Tirole, J., 1997. Formal and real authority in organizations. Journal of Political Economy 105 (1), 1–29.

Amiti, M., Smarzynska Javorcik, B., 2008. Trade costs and location of foreign firms in China. Journal of Development Economics 85 (1–2), 129–149.

Antràs, P., 2003. Firms, contracts and trade structure. Quarterly Journal of Economics 118 (4), 1375–1418.

Antràs, P., 2005. Incomplete contracts and the product cycle. American Economic Review 95 (4), 1054–1073.

Antràs, P., 2011. Grossman-Hart (1986) Goes Global: Incomplete Contracts, Property Rights, and the International Organization of Production. Mimeo Harvard University.

Antràs, P., Chor, D., 2011. Organizing the Global Value Chain. Mimeo Harvard University.

Antràs, P., Helpman, E., 2004. Global sourcing. Journal of Political Economy 112 (3), 552–580.

Antràs, P., Helpman, E., 2008. Contractual frictions and global sourcing. In: Helpman, E., Martin, D., Verdier, T. (Eds.), The Organization of Firms in a Global Economy. Harvard University Press.

Bartelsman, E.J., Gray, W., 1996. The NBER Manufacturing Productivity Database. Technical Working Paper No. 205 National Bureau of Economic Research.

Bergin, P., Feenstra, R., Hanson, G., 2009. Offshoring and volatility: evidence from Mexico's maquiladora industry. American Economic Review 99 (4), 1664–1671.

Bergin, P., Feenstra, R., Hanson, G., 2011. Volatility due to offshoring: theory and evidence. Journal of International Economics 85 (2), 163–338.

Bernard, A., Jensen, J., Redding, S., Schott, P., 2007. Firms in international trade. Journal of Economic Perspectives 21 (3), 105–130.

Bernard, A., Jensen, J., Redding, S., Schott, P., 2008. Intra-firm Trade and Product Contractibility. Mimeo, Yale School of Management.

Bernard, A., Jensen, J., Schott, P., 2009. Importers, exporters and multinationals: a portrait of firms in the U.S. that trade goods. In: Dunne, T., Jensen, J.B., Roberts, M.J. (Eds.), Producer Dynamics: New Evidence from Micro Data. University Of Chicago Press.

Conconi, P., Legros, P., Newman, A.F., 2008. Trade Liberalization and Organizational Change. CEPR Discussion Paper No. 7028 .

Corcos, G., Irac, D., Mion, G., Verdier, T., 2008. The Determinants of Intra-Firm Trade. Centro Studi Luca D'Agliano Working Paper No. 267 .

Defever, F., Toubal, F., 2007. Productivity and the Sourcing Modes of Multinational Firms: Evidence from French Firm-Level Data. CEP Discussion Paper No. 842 .

Feenstra, R., Hanson, G., 2005. Ownership and control in outsourcing to china: estimating the property-rights theory of the firm. Quarterly Journal of Economics 120 (2), 729–761.

Grossman, G., Helpman, E., 2002. Integration versus outsourcing in industry equilibrium. Quarterly Journal of Economics 117 (1), 85–120.
Grossman, G., Helpman, E., 2003. Outsourcing versus FDI in industry equilibrium. Journal of the European Economic Association 1 (2–3), 317–327.
Grossman, G., Helpman, E., 2004. Managerial incentives and the international organization of production. Journal of International Economics 63, 237–262.
Grossman, G., Helpman, E., 2005. Outsourcing in a global economy. Review of Economic Studies 72 (1), 135–159.
Head, K., Mayer, T., 2004. Market potential and the location of Japanese investment in the European Union. The Review of Economics and Statistics 86 (4), 959–972.
Helpman, E., 2006. Trade, FDI, and the organization of firms. Journal of Economic Literature 44, 589–630.
Helpman, E., Melitz, M., Yeaple, S., 2004. Export versus FDI with heterogeneous firms. American Economic Review 94 (1), 300–316.
Holmstrom, B., Milgrom, P., 1994. The firm as an incentive system. American Economic Review 84 (4), 972–991.
Hummels, D., Ishii, J., Yi, K., 2001. The nature and growth of vertical specialization in world trade. Journal of International Economics 54 (1), 75–96.
International Labour Organization, 2007. Export Processing Zones: Epz Employment Statistics. Available from, http://www.ilo.org/public/english/dialogue/sector/themes/epz/stats.htm.
Kohler, W., Smolka, M., 2009. Global Sourcing Decisions and Firm Productivity: Evidence from Spain. CESifo Working Paper No. 2903.
Levchenko, A., 2007. Institutional quality and international trade. Review of Economic Studies 74 (3), 791–819.
Manova, K., 2007. Credit Constraints, Heterogeneous Firms and International Trade. Mimeo, Stanford University.
Marin, D., Verdier, T., 2008. Power inside the firm and the market: a general equilibrium approach. Journal of the European Economic Association 6 (4), 752–788.
Marin, D., Verdier, T., 2009. Power in the multinational corporation in industry equilibrium. Economic Theory 38 (3), 437–464.
McLaren, J., 2000. Globalization and vertical structure. American Economic Review 90 (5), 1239–1254.
Melitz, M., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71 (6), 1695–1725.
Naughton, B., 1996. China's emergence and prospects as a trading nation. Brookings Papers on Economic Activity 2 (1996), 273–343.
Nunn, N., 2007. Relationship-specificity, incomplete contracts, and the pattern of trade. Quarterly Journal of Economics 122 (2), 569–600.
Nunn, N., Trefler, D., 2008. The boundaries of the multinational firm: an empirical analysis. In: Helpman, E., Martin, D., Verdier, T. (Eds.), The Organization of Firms in a Global Economy. Harvard University Press.
Nunn, N., Trefler, D., 2011. Incomplete Contracts and the Boundaries of the Multinational Firm. Mimeo, Harvard University.
Ornelas, E., Turner, J., 2009. Protection and International Sourcing. Mimeo, LSE.
Puga, D., Trefler, D., 2003. Knowledge Creation and Control in Organizations. NBER Working Paper No. 9121 .
Rajan, R., Zingales, L., 1998. Financial dependence and growth. American Economic Review 88 (3), 559–586.
Romalis, J., 2003. Factor proportions and the structure of commodity trade. American Economic Review 94 (1), 67–97.
Sheng, Yang, 2011. Processing Trade, Ownership Structure, and Wage Inequality: Theory and Evidence from China. mimeo, University of California, Davis.
Yeaple, S., 2006. Offshoring, foreign direct investment, and the structure of U.S. trade. Journal of the European Economic Association 4 (2–3), 602–611.