The Ownership Structure of Offshoring and Wage Inequality: Theory and Evidence from China†

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Abstract

We develop a model to study the joint determination of the ownership structure of offshoring, skill upgrading, and wage inequality in developing countries. Because of the abundance in low-skilled labor and contractual frictions in the South, the skill content of intra-firm offshoring dominates that of arm's length offshoring. As a result, processing trade by foreign owned firms has a greater effect on skill upgrading and skill premium in developing countries compared with that by joint ventures and indigenous firms. We test these theoretical implications with a natural experiment in which China lifted its restrictions on foreign ownership upon its accession to the WTO. Empirical findings using detailed Urban Household Surveys and trade data from Chinese customs provide strong support to the proposed theory, shedding light on the changes in firm ownership structures, the skill content of exports, and the evolution of wage inequality over the past two decades in China.

Keywords: ownership structure, processing trade, skill premium, contractual environment, China

JEL code: F16, J31, D23

1 Introduction

The nature of international trade has changed. For centuries, conventional trade involves the exchange of final goods among firms located in different geographic regions. Now trade in intermediate inputs – through both arm's length transactions and trade within firm boundaries – has become a prominent feature of the global economy. Using input-output table and bilateral trade data for 113 countries and regions, Johnson and Noguera (2011) conclude that trade in intermediate inputs today accounts for as much as two thirds of international trade. The organizational structure of trade has also chanced. Revolutionary innovations in transportation and communication technologies, such as the container ship and the Internet, have made multinational companies the dominant player in world trade, and also significantly promoted intrafirm trade. As a result, roughly one-third of world trade was within firm boundaries in 1996 (UNCTAD, 1999, p.232). Because most of intrafirm trade involves exchanges in intermediate inputs, thus intrafirm offshoring contributes about a third to a half to total offshoring. The rising offshoring and changes in organizational form raise important questions for the determination of factor prices. Does the effect of offshoring on wage inequality differ from that of conventional trade? Do intrafirm offshoring and arm's length offshoring have differential effects on relative wages?

Trade economists have studied the impact of offshoring on factor prices, initially as a remedy to the failure of Heckscher-Olin model in explaining the rising wage inequality in both developed and developing countries in the last three decades. [1] Recent studies by Grossman and Rossi-Hansberg (2008) and Baldwin and Robert-Nicoud (2010) have treated offshoring as the core of trade and explored its general implications on wage inequality. However, most of the studies focus on the effect of offshoring on wage inequality in developed countries, while the rising college premium in developing countries is even more puzzling. [2] Moreover, this literature mainly focuses on the

[1] See, for example, Feenstra and Hanson (1996b), Feenstra and Hanson (1997), Hsieh and Woo (2005), Zhu and Trefler (2005).

[2] Stolper-Samuelson theorem suggests that globalization should help low-skilled workers in developing countries because they are the locally abundant productive factor. However, overwhelming evidence shows that globalization has increased the income of high-skilled workers relative to that of low-skilled workers in developing countries (Goldberg and Pavcnik, 2007).

impact of aggregate size of offshoring on wage inequality, but does not distinguish the ownership structure of offshoring, i.e., intra-firm offshoring and arm's length offshoring. This is an important omission in light of the extensive evidence showing that multinationals are more likely to offshore capital (or headquarter service and communication) intensive and more sophisticated tasks through their foreign affiliates,[3] and given that multinationals become an increasingly prominent feature of world economy (Ramondo and Rodríguez-Clare, 2009).

In this paper, we construct a general equilibrium model where multinational companies make joint decision of ownership structure, production location, and skill demand. We show that the skill content of intra-firm offshoring (by foreign owned firms) is higher than that of arm's length offshoring (by joint ventures and Southern domestically-owned firms) in developing countries. Thus, the intrafirm offshoring has a major effect on the skill upgrading in export structure and the rising skill premium in developing countries, while the arm's length offshoring may not have a significant effect.

Our main innovation in modeling is to introduce the ownership choice into the offshoring model by Feenstra and Hanson (1996a), where the ownership choice is based on the classical Property Rights Theory (PRT) of firms (Grossman and Hart, 1986; Hart and Moore, 1990). The model integrates the features of comparative advantage of factor endowments and incomplete contracts, but disentangles their roles in global production specialization. The model retains the main implication of comparative advantage: the more skill-intensive products remain in the North, and the less skill-intensive goods are offshored to the South (Dornbusch et al., 1980). Among these offshored goods, the model also provides a complete characterization of ownership structure of offshoring, in which intra-firm offshoring is more skill intensive than arm's length offshoring.

In drawing the firm ownership structure, we follow the seminal work of Grossman and Hart (1986) and Antràs (2005). We consider the setting of incomplete contracts in which for each product, the Northern innovator has the blueprint to produce high-tech inputs using high skilled

[3]See, for example, Grossman and Helpman (2002, 2004, 2005), Antràs (2003), Antràs and Helpman (2004), Antràs (2005), Antràs et al. (2006), Feenstra and Hanson (2005), Nunn and Trefler (2008), Costinot et al. (2011), and Fernandes and Tang (2010).

labor, but needs to find a supplier of low-tech inputs, which are produced by low-skilled labor. Both parties engage in the relation-specific investments for this unique product. The contract is complete in the North but not in the South because no outside court can verify quality of the inputs of both parties due to poor legal protection (Nunn, 2007; Levchenko, 2007). The nature of the incomplete contracts leads to a classical holdup problem, which can be ameliorated by ownership choice. Thus, Northern innovators' offshoring decision in nature involves the choice of firm ownership structure among Northern foreign ownership, joint venture, or Southern domestic ownership.

Following the property-rights approach of Grossman and Hart, ownership of the joint production entitles the firm's owner to some residual rights control, thus improving his ex-post bargaining position, but reducing the other party' ex-ante incentive to make relation-specific investment. Thus, the optimal ownership structure should give the residual right to the party whose investment is more important for the relation-specific investments. In our case, among those goods offshored to the South, it would be better if the Northern innovator owns the firm for more skill-intensive products, since she has control over the high-tech input. On the contrary, if less skill-intensive products are involved, Southern ownership is optimal because the investment in low-tech inputs by the local supplier is more important. If both inputs are crucial, then joint ownership would be optimal.

Combined with the implication of comparative advantage, our model depicts a complete picture of global production sharing. The most skill-intensive products remain in the North, the next more skill-intensive products are offshored to the South by foreign owned firms, and the less skill-intensive products are offshored through joint ventures and Southern-owned firms.[4] Thus, it is easy to see that more skill-intensive products are less likely to be offshored to the South if foreign ownership is limited in the South. In contrast, relaxing ownership restrictions can significantly upgrade the export structure of the South in terms of skill intensity, and thus increase the demand for high-skilled labor. A new result is that ownership change itself increases the demand for high-skilled labor because foreign-owned firms have incentive to provide more high-tech inputs by

[4]This property is complementary to Antràs and Helpman (2004), in which the most productive firms in the headquarter-service-intensive sector prefer vertical integration over arm's length outsourcing, as well as Li (2009), in which the communication-intensive industries adopt intrafirm offshoring.

hiring more skilled workers given the same product.

We test our theory empirically using the natural experiment of ownership liberalization in which China lifted its restrictions on foreign ownership upon its accession to the WTO in 2001. China has imposed foreign ownership restriction in early 1990s, and with its accession to the WTO, it has undertaken a major legal and economic reform to remove barriers to foreign trade and investments. These policy reforms along with trade liberalization have successfully transformed China from a negligible player in international markets to the world's largest exporter in 2010, and to the largest recipient of FDI among developing countries. One remarkable structural change is that foreign-owned firms began to play the dominant role in both processing exports and FDI after 2001.

Figure 1 presents processing exports by ownership for the 1992-2008 period, highlighting the role of foreign-owned firms in the recent surge in China's exports.[5] The processing exports by foreign-owned firms experienced steady growth in the 1990s, reaching 52 billion USD in 2000. Since then, the growth has exploded, reaching 434 billion USD in 2008, which accounts for 64 percent of China's processing exports. Similar changes in ownership structures are observed in the FDI inflows. Joint ventures played the dominant role in FDI before 2001. However, foreign-owned firms accounted for 78 percent of China's annual FDI in 2008 (NBS, 2009).

Coincidentally, the college wage premium in the Chinese manufacturing sector stayed flat before China's accession to the WTO in 2001, but dramatically increased thereafter. In Figure 2 we compute the college wage premium based on the national representative sample of Chinese Urban Household Surveys (CUHS), collected by the National Bureau of Statistics (NBS) and to which we have unique access. The earnings gap between those with and without a college education was about 30 percent throughout the 1990s, but this skill premium rose to 55 percent in 2006.

Are these two facts mere coincidences or causally linked? Our conjecture is that liberalization

[5]Processing exports are an activity that involves a firm in China importing intermediate goods from aboard, using the input for production, and then exporting the finished goods to international markets. Imported intermediate input is duty-free as long as it is used only for export (Feenstra and Hanson, 2005). In other words, processing exports are the offshored production from developed countries. Processing exports play a major role in China's international trade, accounting for 53 percent of the country's total export from 1992 to 2008.

toward foreign ownership of capital may account for both the changes in export pattern and the college wage premium in China. China has rich spatial diversions across provinces, thus we can take the advantage of the geographic differential in exposure to trade and labor market to test our theory. We derive three testable hypotheses from the model: the skill intensity hypothesis, the distributional hypothesis, and the college premium hypothesis. The skill intensity hypothesis states that intra-firm offshoring is more skill-intensive than arm's length offshoring by joint ventures and Southern-owned firms. The distributional hypothesis states that regions (or industries) in the South with a higher degree of ownership flexibility, a better contract environment, and lower trade costs have more intra-firm offshoring. The college premium hypothesis states that regions with more offshoring and a higher share of intra-firm offshoring have higher college premium.

The primary data sources we use are the Chinese customs trade data (1992-2008) and CUHS (1992-2006). For the first hypothesis, we find that the average skill intensity of processing exports by foreign-owned firms is the highest among all firms. Moreover, the first-order stochastic dominance test suggests that the processing export distribution by foreign owned firms have strictly dominated those of joint ventures and Chinese-owned firms since 1998, implying that the skill upgrading is the most significant in the export by foreign-owned firms, especially in 2000s. For the second hypothesis, we construct a unique measure of ownership liberalization at the 4 digits ISIC industry level over years, based on a series of government industrial policies, specifying in which industries foreign ownership is encouraged, restricted, or prohibited for foreign capitals. As a result, we find that a high degree of ownership liberalization, a better contract environment, and trade cost reduction increase processing exports by foreign-owned firms more than those by other firms.

For the third hypothesis, we find that both the size of processing exports and the processing exports share of foreign-owned firms are important determinants of college wage premium. This result is also robust to various controls of alternative theories: skill-biased technology (measured as R&D expenditure and the import share of equipment) and capital complementarity (measured as the capital-to-output ratio). As a result, a one percentage point increase in the processing export-to-

GDP ratio and the share of foreign-owned firms in processing exports are associated with 0.77 and 0.24 percentage points increase in the college wage premium (log wage differential), respectively. Because China's processing export ratio and the share of foreign-owned firms have increased by 7.8 and 24.6 percentage points from 2000 to 2006, each of them contributed 6 and 5.9 percentage points, respectively, to the increase in the college wage premium. Overall, they account for 80 percent of the total increase in the college wage premium between 2000 and 2006. Since foreign-owned firms contribute 63 percent to total processing export in 2006, the processing export by foreign-owned firms itself can account for 65 percent of the increase in the skill premium.

This paper contributes to the literature on the organizational forms of multinationals in global production. As discussed above, previous studies mainly focus on the determinants of organizational forms, while the general equilibrium structure is largely ignored.[6] We are not aware of any previous work that has focused on the ownership liberalization as a mechanism linking offshoring and labor-market outcomes. This paper bridges the gap by providing an integrated framework to analyze the effect of ownership liberalization, trade cost reduction, and improvement in contract environment on trade pattern and wage inequalities in developing countries. Understanding the linkage between ownership structure of offshoring and wage inequality also have important policy implications because the limitation on foreign ownership is the most obvious barrier to inward FDI. Moreover, in the last three decades many countries have undertaken ownership liberalization to encourage inward FDI (Kalinova et al., 2010). However, the effect of ownership liberalization on trade structure and factor prices is still largely unknown. Our empirical results based on the experience in China, certainly cast lights on the hidden area.

This paper contributes to the literature concerning the relationship between globalization and wage inequality in two folds. First, most recent studies exploring the role of firm heterogeneity in the rising demand for high-skilled labors are based on the sorting mechanism à la Melitz (2003)[7],

[6]Besides the above mentioned studies, please see Helpman (2006) for a comprehensive review of trade, FDI and firm organizations. As Grossman and Rossi-Hansberg (2008) comment: "Part of this literature focuses on a firm's choice of organizational form. Although this is an interesting problem, the models used to address it tend to be complex, incorporating imperfect information and subtle contracting or matching problems, and so the general equilibrium structure has been kept to a bare minimum."

[7]See, for example, Bustos (2011) discusses the channel through firms' choice of skill-biased technology adoption.

whereas our approach focuses on the heterogeneous organizational forms of offshoring, and thus has stronger policy implications for developing countries. Secondly, although the impact of globalization and wage inequality has been extensively explored among many developing countries, there has been limited research on China (Goldberg and Pavcnik, 2007), with an exception of Han et al. (2011).[8] This is a serious void in the literature because China has emerged rapidly as the "workshop of the world" and experienced profound changes in income distribution in recent decades. Our research covers all provinces of China except Tibet, and also the years from 1992 to 2006, which cover both before and after China's entry to the WTO. Thus, our case study of China sheds light on the effect of the recent wave of globalization on income inequality in developing countries.

This paper is also related to the recent growing literature concerning the relationship between institutional quality and trade pattern (Nunn, 2007; Levchenko, 2007; Lu et al., 2008; Du et al., 2008; Feenstra et al., 2010). We show that ownership liberalization of foreign capital has a threshold effect on the skill upgrading of export structure and the rising skill demand in developing countries. Moreover, it contributes to the literature also by exploring efficiency loss due to poor contract environment both from the intensive margin and extensive margin of export. Consistent with Feenstra et al. (2010), we also find that better contract environment encourages more intra-firm offshoring than arm's length offshoring.

This paper is organized as follows. Section 2 develops the theoretical framework. Section 3 proposes three hypotheses, and presents the background of China and our data. Section 4 tests three hypotheses and presents the empirical findings. The final section concludes with policy discussions.

Verhoogen (2008) explores the quality upgrading channel. Helpman et al. (2010) provides a tractable model to explore the determinants of wage distributions that emphasize within-industry reallocation, labor market frictions, and differences in workforce composition across firms

[8] Han et al. (2011) also find that wage inequality was rising in China, using a part of CUHS data that cover five provinces. Their study is purely empirical and does not provide a theoretical explanation.

2 An Offshoring Model with Ownership Choice

This model introduces ownership structure into the offshoring decision in a two-country model, showing how firms jointly decide on offshoring, ownership forms and skill demand subject to trade frictions and incomplete contracts.

2.1 Setup

The world consists of two countries, the North and the South. There are two types of labor: high and low skilled labors, denoted by h and l respectively. Their wages in country c are denoted by q^c and w^c, respectively, where $c \in \{N, S\}$. The North has more abundant high-skilled labor than the South.

The final good production technology is given by $Y = \log(\int_0^1 y^\alpha(z)dz)^{1/\alpha}$, a pure assembly of intermediate goods. We assume that the North produces both the final good Y and intermediate goods, while the South only produces intermediate goods. Firms in the South need to export their products to the North, and the trade cost is modeled as Samuelsonian iceberg cost, denoted by $t \geq 1$. The South must send t units of goods for one unit to arrive for sale in the North.

The production of the intermediate good $y(z)$ is given by

$$y(z) = (\frac{x_h}{z})^z(\frac{x_l}{1-z})^{1-z} \tag{1}$$

where x_h is the high-tech input, which requires the high-skilled labor, and x_l is the low-tech input produced by the low-skilled labor. For simplicity, we assume linear production functions for these inputs: one unit of high-tech (low-tech) input requires one unit of high-skilled (low-skilled) labor. [9] We also assume that the production for each intermediate good $y(z)$ is not fragmentable, i.e., the two inputs have to be produced at the same location for manufacturing the good z. [10]

[9] This assumption simplifies the model, but the model can be extended to have different labor productivities.

[10] We follow the approach of Feenstra and Hanson (1996a, 1997) to offshoring, where intermediate goods can be offshored, but the production of intermediate goods is not fragmentable. In contrast, Grossman and Rossi-Hansberg (2008) and Antràs (2005) assume fragmentable production, i.e., the North can offshore the high or low input production to the South separately. Please see Feenstra (2010) for a nice discussion of these two approaches and their implications

For any intermediate good z, only the Northern innovator has the technology (blueprint) to produce the high-tech input, but she has to find a low-tech input supplier in the North or South. Two parties' investments are assumed to be relation specific: the Northern innovator tailors the high-tech input and the supplier customizes its low-tech input. Thus, both parties' inputs are useless outside the relationship. As the Northern innovator enters, the supplier needs to pay her a lump-sum transfer T because ex ante there are a large number of identical and potential suppliers competing for the job. This lump-sum transfer would make the supplier break even.

The setting is one of the incomplete contracts in the situation of global production sharing. In particular, we assume that only when two agents are both in the North can an outside party (court) distinguish between a good-quality and a bad-quality input. However, the Northern innovator and the Southern supplier cannot sign an enforceable contract specifying a certain type of quality for inputs for a certain price. If they did, the party that receives positive payment has incentives to provide a low quality input. Hence, this leads to the classic holdup problem impeding the Northern innovators from offshoring. However, the Northern innovators can choose the ownership of their joint production to ameliorate the holdup problem created by the incomplete contracts. Let the variable O denote whether the Northern innovator owns the firm ($O = F$), or the Southern supplier owns it ($O = D$), or both parties share the ownership, i.e., joint venture ($O = J$).

Timing proceeds as follows: in period 0, the Northern innovator of the intermediate good $y(z)$ chooses to locate production in country $c \in \{N, S\}$, and she offers a contract to the low-tech supplier consisting of ownership choice and an ex-ante transfer. In period 1 both parties simultaneously hire high-skilled and low-skilled workers to produce high and low tech inputs respectively. In period 2, the firm ships the intermediate good z and sells it to the final good producer in the North.

In this simple framework, the Northern innovator makes the joint decision of offshoring, ownership structure and skill demand, given the behavior of other producers. Based on the final good production function, we can derive the factor demand curve for this unique intermediate good $y(z)$

of offshoring and wage inequality.

as follows:

$$y(z) = \lambda p(z)^{-1/(1-\alpha)}, \quad 0 < \alpha < 1 \tag{2}$$

where λ is a function of total expenditure and an aggregate price index. Hence, $p(z) = (\lambda/y(z))^{1-\alpha}$ and the revenue is $R(z) = \lambda^{1-\alpha}y(z)^{\alpha}$.

2.2 Production in the North

Consider a Northern innovator who locates her production in the North. Because the contract is complete in the North, the organizational choice is irrelevant since the institutional environment in the North fully enforces the contracts between the innovator and the supplier. Under this scenario, the Northern innovator requests the supplier to provide the low-tech x_l, along with her own high-tech x_h, to maximize her profit as follows:

$$\max_{x_h, x_l} \pi = R - q^N h^N - w^N l^N$$
$$s.t.\ R(z) = \lambda^{1-\alpha} y^{\alpha}$$

This yields the investment bundle (h^{N*}, l^{N*}). The innovator pays $w^N l^*$ to the supplier, and sets the lump-sum transfer $T = 0$. Thus, she has the following profit:

$$\pi^N(z) = (1-\alpha)\lambda[\alpha(1/q^N)^z(1/w^N)^{(1-z)}]^{\alpha/(1-\alpha)} \tag{3}$$

2.3 Production in the South

If the Northern innovator chooses to locate her production in the South, contracts specifying the purchase of a certain type of input for a certain price are not enforceable. As a result, the innovator and the supplier can only bargain over the surplus from their joint production after the inputs have been produced. This ex post bargaining is modeled as a generalized Nash bargaining game in which the innovator obtains a fraction $\beta \in (0, 1)$ of the ex post revenue, where the value of β depends on the organizational forms, as we will discuss below. If both parties produce good quality inputs, then the potential revenue from the sale of the good is $R(z) = \lambda^{1-\alpha} y^{\alpha}/t^{\alpha}$. Thus, the supplier sets l^S to maximize $(1-\beta)R(z) - w^S l^S$, and the innovator sets h^S to maximize $\beta R(z) - q^S h^S$. Combining the two first order conditions yields the optimal revenue as follows:

$$R(z,\beta) = \lambda(\frac{1}{t})^{\alpha/(1-\alpha)}[\alpha(\beta/q^S)^z((1-\beta)/w^S)^{(1-z)}]^{\alpha/(1-\alpha)} \quad (4)$$

Setting T so as to make the low-tech supplier break even leads to the following expression for the Northern innovator's ex ante profits:

$$\pi^S(z,\beta) = \lambda(\frac{1}{t})^{\alpha/(1-\alpha)}[\alpha(\beta/q^S)^z((1-\beta)/w^S)^{(1-z)}]^{\alpha/(1-\alpha)}[1-\alpha\beta z - \alpha(1-\beta)(1-z)] \quad (5)$$

where $\alpha \in (0,1)$and β, $z \in [0,1]$.

Ownership gives the owner of the firm the residual rights and thus changes the two parties' ex post outside values. If the Northern innovator owns the firm ($O = F$), once they did not achieve agreement on the bargaining, the innovator can fire the low-tech supplier, who will be left nothing. But she can still obtain an amount of $\delta_F y$ output, which in turn generates sale revenue of $\delta_F^{\alpha} R$. The quasi-rent of this relationship is $(1-\delta_F^{\alpha})R$. Symmetric Nash Bargaining leaves each party with its outside option plus one-half of the quasi-rent. Thus, the ex post share of the Northern innovator in revenue is $\beta^F = \frac{1}{2}(1+\delta_F^{\alpha})$, which leaves the low-tech supplier $1-\beta^F = \frac{1}{2}(1-\delta_F^{\alpha})$ of the revenue. For the case of joint ownership ($O = J$), both parties have veto power and their outside options are zero, thus symmetric Nash Bargaining implies that the innovator's share in revenue is $\beta^J = 1/2$. If the low-tech input producer owns the firm ($O = D$), the innovator's share in revenue is $\beta^D = \frac{1}{2}(1-\delta_D^{\alpha})$. Clearly, the share of revenue is higher for the party who has more control over the firm. For the Northern innovator we have $\beta^D < \beta^J < \beta^F$.

2.4 Location and ownership choice

The Northern innovator chooses production locations as well as the optimal form of ownership if she chooses to offshore. Therefore, her ex ante expected profit is

$$\pi(z) = \max_{c\in\{N,S\},O\in\{F,J,D\}} \{\pi^N(z), \pi^S(z,\beta^D), \pi^S(z,\beta^J), \pi^S(z,\beta^F)\} \tag{6}$$

Comparing to the North, the South has abundant cheap low-skilled labor, but it has the iceberg trade cost and efficiency loss due to the incomplete contracts. To separate the effect of comparative advantage and trade costs from the effect of incomplete contracts on offshoring, we introduce a hypothetical case where the South also has complete contracts. The procedure to derive the profit for a given intermediate good z under the complete contracts in the South, denoted as $\pi^S(z)$, is similar to the case of production in the North, thus it is easy to show $\pi^S(z) = (1-\alpha)\lambda[\alpha(1/q^s)^z(1/w^s)^{(1-z)}]^{\alpha/(1-\alpha)}(1/t)^{\alpha/(1-\alpha)}$.

We first consider an artificial case when both the North and South have complete contracts. Let $N(z)$ denote the "log profit ratio" of the Northern production relative to the Southern production both with complete contracts:

$$N(z) \equiv \frac{1-\alpha}{\alpha}\ln(\pi^N(z)/\pi^S(z)) = z\ln(\omega_l/\omega_h) - \ln\omega_l + \ln t \tag{7}$$

where $\omega_h = q^N/q^S$, and $\omega_l = w^N/w^S$. At the cutoff z^* the Northern innovator is indifferent of locations, i.e., $\pi^N(z^*) = \pi^S(z^*)$ or $N(z^*) = 0$, thus we get $z^* = (\ln\omega_l - \ln t)/(\ln\omega_l - \ln\omega_h)$. The North has more abundant high-skilled labor, which implies that $\omega_h < \omega_l$. To rule out the extreme case that all products are produced in one location, we assume the following assumption.

Assumption 1 $\omega_h < t < \omega_l$.

Based on this assumption, we can show the following lemma.

Lemma 1 *Assuming that both countries have the complete contracts and Assumption 1 holds, we have $z^* \in (0,1)$, and for any $z > z^*$, $\pi^N(z) > \pi^S(z)$ and for any $z < z^*$, $\pi^N(z) < \pi^S(z)$. Thus,* *more skill-intensive intermediate goods are produced in the North, and the less skill-intensive intermediate goods are offshored to the South. Moreover, z^* increases as the trade cost decreases.*

Proof. It is easy to show that the assumption 1 guarantees an interior solution $z^* \in (0, 1)$, and $N(z)$ increases in z. Thus, for $z > z^*$, $N(z) > N(z^*) = 0$, and $\pi^N(z) > \pi^S(z)$, and vice versa. In this case, our model is the same as in Feenstra and Hanson (1997) where comparative advantage plays a crucial role in the allocation of global production sharing. Moreover, the trade cost dampens the South's comparative advantage, and a reduction in trade costs can attract more skill-intensive products to the South.

Similarly, we define the "log profit ratio" of the Southern production under different ownership types, relative to the Southern production with the complete contracts as follows:

$$\begin{aligned} S(z,\beta) &\equiv \frac{1-\alpha}{\alpha}\ln(\pi^S(z,\beta)/\pi^S(z)) \\ &= z\ln\frac{\beta}{1-\beta} + \ln(1-\beta) + \frac{1-\alpha}{\alpha}[\ln(1-\alpha\beta z - \alpha(1-\beta)(1-z)) - \ln(1-\alpha)] \end{aligned} \tag{8}$$

where $\beta \in (0, 1)$. This normalization procedure peels off most of common factors in the profit function of $\pi^S(z, \beta)$, such as demand shift λ, factor prices and trade costs, but highlights the key factor for ownership choice. The next lemma shows an important feature of $S(z, \beta)$.

Lemma 2 *$S(z, \beta)$ is supermodular in (z, β), concave in z, and strictly concave in β. For a given value of z, there is a unique maximizer $\beta^*(z) \in [0, 1]$, and $\beta^*(z)$ increases in z.*

Proof appears in Appendix A. Since $S(z, \beta)$ is continuous and differentiable, we only need to show $\frac{\partial^2 S(z,\beta)}{\partial z \partial \beta} > 0$ for supermodularity, according to Milgrom and Roberts (1990) and Topkis (1998). Supermodularity implies that the Northern innovator's bargaining power is complementary to the skill intensity of the intermediate goods z. This is also the core spirit of the PRT of firms (Grossman and Hart, 1986; Hart and Moore, 1990), which argues that the optimal ownership structure should give the residual rights to the party whose investment is more crucial to the relation-specific investment. More formally, the appendix shows that there is a unique maximizer $\beta^*(z) \in [0, 1]$ for a given value of z, and $\beta^*(z)$ increases in z due to supermodularity.

In our case, three ownership types correspond to three unique values of β. Thus, for the most skill-intensive intermediate goods produced in the South, it would be optimal if the Northern innovator owns the firm ($O = F$) since she has control over the high-tech input. While for the least skill-intensive intermediate goods, it would be optimal for the Southern domestic ownership ($O = D$) since the local supplier's investment in low-tech input is more important. If both inputs are important, then joint ownership would be optimal($O = J$). The following lemma formally proves this statement (see the proof in Appendix B).

Lemma 3 *If the Northern innovators would offshore all intermediate goods to the South, the most skill-intensive intermediate goods are offshored through Northern-owned foreign firms ($z > z^*_{JF}$), and the next more-skill-intensive are offshored through joint ventures ($z^*_{DJ} \leq z \leq z^*_{JF}$), and the least skill-intensive are outsourced to the Southern-owned domestic firms ($z < z^*_{DJ}$). Moreover, these cutoffs (z^*_{DJ} and z^*_{JF}) are independent of trade costs.*

Figure 3 plots $N(z)$ and $S(z, \beta^O)$ where $O = F, J, D$. The horizontal zero line is the log profit ratio of $\pi^S(z)$. The upward sloping line $N(z)$ implies that the profit is higher for more skill-intensive intermediate goods to be produced in the North. This statement also holds for the upward sloping curve $S(z, \beta^F)$, namely the foreign ownership of the Southern production. In contrast, the negative sloping curve $S(z, \beta^D)$ implies that it becomes less profitable to choose Southern ownership for more skill-intensive products. Meanwhile, Lemma 3 implies that the optimal offshoring profits should be the upper contour of the log profit ratios of three ownership types, if the whole spectrum of intermediate goods would have been offshored to the South. This upper contour is below zero, implying that allocation of property rights can not recover the efficiency loss due to the incomplete contracts. This is fundamental feature of PRT, i.e., the allocation of residual rights increases one party's incentive but decreases the others (Grossman and Hart, 1986). Thus, the area between the upper contour of $S(z, \beta^O)$ for $O = F, J, D$ and the horizontal zero line is the efficiency loss due to the incomplete contracts.

Figure 3 also suggests the solution to the Northern innovator's joint choice of location and organizational form. The optimization problem in equation (6) is equivalent to comparison between the log profit ratios of North and South productions with three ownership choices ($N(z)$ and $S(z, \beta^O)$ for $O = F, J, D$). To formally show the solution, we make the following assumption:

Assumption 2 *(1)* $\omega_h < t$*; (2)* $\omega_l > \frac{t}{1-\beta^F}[\frac{1-\alpha}{1-\alpha(1-\beta^F)}]^{\frac{1-\alpha}{\alpha}}$.

The first part is the same as in Assumption 1, which guarantees that the most skill-intensive product $z = 1$ is produced in the North, even assume the South also had the complete contracts. The second part guarantees that the least skill-intensive product is produced in the South, i.e. $N(0) < S(0, \beta^F)$. This implies $\beta^F < \widetilde{\beta} \equiv f^{-1}(\omega_l/t)$, where $f(\beta) = \frac{1}{(1-\beta)}[\frac{1-\alpha}{1-\alpha(1-\beta)}]^{\frac{1-\alpha}{\alpha}}$. The intuition for this upper bound is that the South supplier has little incentive to invest in low-tech input if his revenue share $(1 - \beta)$ is close to 0. Note $f(\beta)$ is an increasing function from 1 to infinity. Thus, if β^F satisfies this inequality, it is easy to show that this inequality also holds for β^J and β^D. Based on this assumption, we can show our main proposition(see the proof in Appendix C).

Proposition 1 *If Assumption 2 holds, there exists a unique triple* $(z^*_{FN}(t), z^*_{JF}, z^*_{DJ})$*, such that the most skill-intensive intermediate goods remain in the North (*$z > z^*_{FN}(t)$*), the more skill-intensive are offshored through Northern-owned foreign firms (*$z^*_{FN}(t) > z > z^*_{JF}$*), the less skill intensive are offshored through joint ventures (*$z^*_{DJ} \leq z \leq z^*_{JF}$*), and the least skill-intensive are outsourced to Southern-owned firms (*$z < z^*_{DJ}$*). Moreover, as the trade cost* t *decreases,* $z^*_{FN}(t)$ *increases.*

Note that under certain conditions, foreign ownership may not be an optimal arrangement for any of the intermediate inputs. For instance, if the trade cost is very high, the log profit ratio of Northern production $N(z)$ does not have interaction with the log profit ratio of Southern production with foreign ownership, namely $S(z, \beta^F)$. Thus, this proposition only shows the case when four production modes coexist, but Figure 3 is sufficient for us to do general analysis. Next we consider three scenarios: trade cost reduction, ownership liberalization and improvement in contract environment.

2.4.1 Trade Cost Reduction

Lemma 1 implies that a reduction in trade costs shifts down $N(z)$, as shown in Figure 4. There are two implications of this effect for offshoring behavior. First, when the trade cost is very high, only Southern-owned firms participate in processing trade, even if joint ventures and foreign ownership are legally allowed. Because the trade cost dampens the comparative advantage of the South, it is only profitable for the North to offshore the lowest skill-intensive products.

Second, as the trade cost declines, it becomes profitable for Northern innovators to offshore more skill-intensive intermediate goods to the South. Meanwhile, the Northern innovators would require more control over their productions in the South. Thus instead of licensing to Southern-owned firms, the Northern innovators would prefer to set up joint ventures or their own greenfield firms in the South. In this case, restriction of foreign ownership would become an important trade barrier.

In addition, a reduction in trade costs has differential effects on the export of Southern firms with different ownership types. More formally, we can show the following proposition:

Proposition 2 *A reduction in trade costs increases the export revenue share of foreign-owned firms in the exports of intermediate products, if three ownership types of firms coexist.*

Proof appears in Appendix D. The intuition is simple: if three ownership types of firms coexist, a reduction in trade costs increases intensive margin for all firms in the South, but increases extensive margin only for foreign-owned firms. Equation 4 shows that the revenue elasticities of the trade cost is $-\frac{\alpha}{1-\alpha}$, irrespective of firm ownership. Thus, a decline in trade costs increases the intensive margin of offshored intermediate goods for all types of firms in the South. However, for the extensive margin, it depends on the location of $N(z)$. If the three ownership types coexist (as depicted in Figure 3), a reduction in trade costs increases the extensive margin of foreign-owned firms, but not for joint ventures or Southern-owned firms, because the cutoffs between ownerships are independent of the trade cost. Thus, the revenue share of the foreign-owned firms in the exports of intermediate products increases.

2.4.2 Ownership Liberalization

Governments in developing countries often restrict the activities of wholly-owned foreign invested firms for reasons including reducing competition with indigenous firms, promoting technology transfer through joint ventures, and controlling strategic sectors (e.g., Kobrin 1987; Gomes-Casseres 1990). Our model provides a framework to analyze the impact of ownership restrictions of foreign capital on the South's export structure.

Consider one extreme case where the Southern government imposes a strict prohibition of foreign-owned firms or joint ventures, and only Southern-owned firms export. Then the cutoff between North-South production is given by z^*_{DN}, as showed in Figure 5. If the trade cost is very high, this ownership restriction policy does not matter much since the Northern innovators would want to outsource their least skill-intensive products to Southern-owned firms. However, if the trade cost is low, then joint ventures and foreign-owned firms are more profitable, thus the South can benefit substantially from relaxing the ownership control for foreign capital. First, if joint ventures and foreign-owned firms are allowed, then the cutoff between North-South production moves up to z^*_{FN}, thus many more skill-intensive products will migrate to the South. Second, there is an efficiency gain from the ownership change from Southern ownership to joint venture and foreign ownership for those products within $[z^*_{DJ}, z^*_{DN}]$.

Another typical case is that the South imposes a prohibition on wholly foreign-owned firms but encourages joint ventures in hope of more technology spillover through learning. This case can be analyzed similarly in Figure 5, and the efficiency gain from liberalization of foreign ownership remains the same. For both cases, as a result of the South's ownership liberalization, the exports by foreign-owned firms will increase, both in intensive and extensive margins, thus the export revenue share of foreign-owned firms will also increase. As a summary, we state the lemma as follows:

Proposition 3 *If the trade cost is lower, i.e., foreign ownership becomes profitable, relaxing ownership restrictions can increase the export revenue share of foreign-owned firms.*

2.4.3 Improvement in Contract Environment

Figure 3 shows the case where the four production modes coexist. This figure shows the additional efficiency loss at the extensive margin due to the incomplete contracts in the South. The Northern innovators would offshore more intermediate goods ($z^*_{FN}(t) < z < z^*$) if the South had the complete contracts. The distance between z^* and z^*_{FN} reflects the extensive margin of the loss due to the incomplete contracts, which in general contains more skill-intensive intermediate goods, and thus affects high-skilled labor more.

Although we do not model the partial incomplete contract explicitly, it is not difficult to see that more products will be offshored to the South if its contract environment becomes better. In Figure 4, an improvement in the contract environment in the South can be approximated by an upward shift in the upper contour of the log profit ratios of three ownership types. [11] It is clear that the cutoff between North-South production $z^*_{FN}(t)$ will increase as the upper contour shifts up, and thus many more skill-intensive products will be offshored to the South through foreign-owned firms.

If the three firm ownership types coexist, and assume an improvement of the contract environment has the same effect on the intensive margin of all South firms' exports, then the combined effect on the intensive and extensive margins of foreign-owned firms' exports implies that the export revenue share of the foreign-owned firms will increase as the contract environment becomes better. As a summary, we state the lemma as follows:

Proposition 4 *If three ownership types of firms coexist, an improvement in contract environment increases the export revenue share of foreign-owned firms.*

[11] We can extend our model to characterize partial complete contracts by assuming the South has complete contract with a positive probability $\phi \in [0, 1]$. Following Sheng and Yang (2011), we can obtain the expected profit for South production with ownership choice O, denoted as $\tilde{\pi}^S(z, \beta^O)$, as the weighted profits of $\pi^S(z)$ and $\pi^S(z, \beta^O)$, with weights ϕ and $1 - \phi$ respectively. Since the log function is concave, and by Jensen's inequality, we know $\ln \tilde{\pi}^S(z, \beta^O) \geq \phi \ln \pi^S(z) + (1 - \phi) \ln \pi^S(z, \beta^O)$. Thus, the log profit ratio of South production $\tilde{S}(z, \beta^O) = (1 - \alpha)/\alpha[\ln \tilde{\pi}^S(z, \beta^O) - \ln \pi^S(z)] \geq (1 - \phi)S(z, \beta^O)$. Clearly, a rise in ϕ can shift up the South production profit, and with the optimal ownership structure, it shifts up the upper contour of three log profit ratios of South production in Figure 4.

2.5 Offshoring, Ownership structure, and Skill premium

In previous sections we have shown that ownership liberalization of foreign capital, along with the trade cost reduction and improvement in contract environment not only increases the export share of foreign-owned firms, but also upgrades the South export structure, because more skill-intensive products are offshored through foreign-owned firms. This section discusses the impact of ownership liberalization on the wage inequality in the South. The subscript S is omitted without causing any confusions in this section.

The general formula of the aggregate relative demand of the high-skilled labor $D(q, w, \overline{z})$ in the South within the interval $z \in [0, \overline{z}]$, is defined as

$$D(q, w, \overline{z}) = \frac{\int_0^{\overline{z}} h(z, \beta) dz}{\int_0^{\overline{z}} l(z, \beta) dz} \tag{9}$$

where β could be β^D, β^J and β^F for different range of z. Next we show the property of the relative skill demand for a given intermediate good.

Proposition 5 *The relative demand for the high-skilled labor for each firm, i.e,* $h(z, \beta)/l(z, \beta) = \frac{\beta z}{(1-\beta)(1-z)} \frac{w}{q}$*, increases in* z *and* β *but decreases in the relative price of the high-skilled labor.*

This proposition reflects two channels that offshoring increases skill demand in the South. First, skill demand increases if more skill-intensive intermediate goods (increase in z) are offshored to the South through the extensive margin. Second, even without the growth in extensive margin, ownership liberalization (increase in β) itself also increases firms' demand for high-skilled labor. This is consistent with the PRT in the sense that the party who owns the firm has more incentive to invest its own input. When the Northern innovator owns the firm, she will hire more high-skilled workers to produce more high-tech input. As the South relaxes its ownership restriction on foreign investment, the relative skill demand will increase for these firms switching from Southern-owned firms or joint ventures to foreign-owned firms. This channel is novel in the literature of the impact of offshoring on labor market.

Proposition 6 *The aggregate relative demand for the high-skilled labor increases in $\overline{z}$, i.e., $\frac{\partial D(q,w,\overline{z})}{\partial \overline{z}} > 0$.*

This is essentially the mechanism of Feenstra and Hanson (1996a). Without loss of generality, we prove the case when three ownership types of firms coexist. The aggregate relative demand for high-skilled labor is given by

$$D(q, w, \overline{z}) = \frac{\sum\limits_{O=D,J,F} \int_{\Omega_O} h(z, \beta^O) dz}{\sum\limits_{O=D,J,F} \int_{\Omega_O} l(z, \beta^O) dz}$$

where $\Omega_D = [0, z^*_{DJ}]$, $\Omega_J = [z^*_{DJ}, z^*_{JF}]$, and $\Omega_F = [z^*_{JF}, \overline{z}]$. Thus,

$$\frac{\partial D(q, w, \overline{z})}{\partial \overline{z}} = \frac{\sum\limits_{O=D,J,F} \int_{\Omega_O} l(\overline{z}, \beta^F) l(z, \beta^O)[h(\overline{z}, \beta^F)/l(\overline{z}, \beta^F) - h(z, \beta^O)/l(z, \beta^O)] dz}{[\sum\limits_{O=D,J,F} \int_{\Omega_O} l(z, \beta^O) dz]^2} > 0$$

due to the fact that $h(\overline{z}, \beta^F)/l(\overline{z}, \beta^F) > h(z, \beta^F)/l(z, \beta^F) \geqslant h(z, \beta^O)/l(z, \beta^O)$ for $z < \overline{z}$, and for $O = D, J, F$. Note that this proposition holds for any distribution of intermediate goods.

Proposition 7 *Given the trade cost is low, ownership liberalization increases the aggregate relative demand for the high-skilled labor, even without considering the growth in extensive margin.*

To make our point clear, we assume that the trade cost is low, allowing three types of firm ownership coexist. For simplicity, we compare the aggregate relative demands of the high-skilled labor for intermediate goods in the range $[0, z^*_{FN}]$, under three ownership arrangements: only Southern-owned firms, only Southern-owned firms and joint ventures, and finally with all three types of ownership. The relative skill demand under three ownership arrangements are denoted by D_1, D_2, D_3. First we redefine $\Omega_F = [z^*_{JF}, z^*_{FN}]$, and $\Omega = \bigcup\limits_{O=D,J,F} \Omega_O$, then the formula for D_1, D_2, D_3 are given as follows:

$$D_1 = \frac{\int_\Omega h(z, \beta^D) dz}{\int_\Omega l(z, \beta^D) dz}$$

$$D_2 = \frac{\int_{\Omega_D} h(z, \beta^D)dz + \int_{\Omega_{J,F}} h(z, \beta^J)dz}{\int_{\Omega_D} l(z, \beta^D)dz + \int_{\Omega_{J,F}} l(z, \beta^J)dz}$$

$$D_3 = \frac{\int_{\Omega_D} h(z, \beta^D)dz + \int_{\Omega_J} h(z, \beta^J)dz + \int_{\Omega_F} h(z, \beta^F)dz}{\int_{\Omega_D} l(z, \beta^D)dz + \int_{\Omega_J} l(z, \beta^J)dz + \int_{\Omega_F} l(z, \beta^F)dz}$$

In Appendix E, we show that $D_1 < D_2 < D_3$ holds under some mild assumptions. Note that D_1(or D_2) is larger than the relative demand for high-skilled labor if only Southern-owned firms (or with joint ventures) are allowed since the cutoff $z^*_{DN} < z^*_{FN}$ (or $z^*_{JN} < z^*_{FN}$).

3 Hypothesis Testing

3.1 Three Testable Hypotheses

Our model generates fruitful predictions about the skill intensity and the regional (or industrial) distributions of the intermediate goods export by different firm ownership, and the impact of offshoring with ownership structure on college premium in the South. To test our model, we propose three testable hypotheses.

Hypothesis I: *Skill intensity hypothesis: The offshored products through foreign-owned firms are more skill intensive than those through joint ventures and Chinese-owned domestic firms.*

This hypothesis is one direct result from Proposition 1. Because we focus on the effect of offshoring on the South, we do not test the skill intensity of North production. A weaker version of this deterministic ranking is stochastic dominance, which captures the idea that foreign-owned firms are relatively better in producing more skill-intensive products. Thus, we adopt stochastic dominance tests for this hypothesis. Note this hypothesis is the building block of our conjecture for the rising college premium in China. Once we show evidence for this hypothesis, we explore the determinants of geographic or industrial distribution of the exports by different ownership forms.

Hypothesis II: *Distributional hypothesis: Regions (or industries) that have lower trade costs, higher degree of ownership liberalization and better contract environment have more export of* *intermediate products by foreign-owned firms.*

This hypothesis is based on Propositions 2, 3, and 4, but is more sophisticated than these propositions, which show that the export revenue share of foreign-owned firms will increase as the South reduces it trade barriers, relaxes ownership restrictions for foreign capital, and improves its contract environment. For our empirical purpose, we explore the differential effects of these factors on the geographic and industrial distribution of the export of intermediate goods by different firm ownership types. Based on the regional difference in the export of intermediate goods and its ownership structure, we can test the third hypothesis.

Hypothesis III: College Premium hypothesis: *Regions that have more offshoring and higher share of foreign-owned firms in offshoring have higher college premium.*

This hypothesis is based on Propositions 6 and 7. It directly tests our conjecture that the offshored production through foreign-owned firms drives up the skill demand in the South. More importantly, it quantitatively evaluates the role of offshoring and the export share of foreign-owned firms, against several other popular theories about the college premium, such as the skill-biased technology theory and the capital-complementarity theory.

3.2 China's Background

China provides a unique opportunity to test these hypotheses, because foreign ownership is restricted or prohibited by the Chinese government in early 1990s, and in late 1990s the country undertook a major legal and economic reform in foreign trade and investment in the face of the WTO accession in 2001. The WTO Agreement on Trade-Related Investment Measures (TRIMs) itself explicitly precludes the WTO members from imposing restrictions or distortions on foreign investment. In order to fully enforce the provisions of the TRIMs agreement, China has modified many laws regulating trade and foreign investment, encouraging foreign firms to compete on an equal basis with Chinese companies. For example, the National Development and Reform Commission has started to announce the industrial policy for regulating foreign capital in 1995, namely the Catalogue for the Guidance of Foreign Investment Industries (NDRC, various years), and revised it subsequently in aiming to relax capital controls gradually. Moreover, China has also improved its legal protection on foreign ownership and intellectual property right in the last two decades. According to Park (2008), the rank of China in internationally patent protection has increased from 69 in 1995 to 34 in 2005, based on the index of patent rights developed by Ginarte and Park (1997). [12]

These policy reforms along with trade liberalization have successfully transformed China from a negligible player in international markets to the world's largest exporter in 2010. Moreover, China has also become the largest recipient of FDI in developing countries and emerged rapidly as the "workshop of the world". Meanwhile, as we discussed above, the foreign-owned firms started to play the dominating role in China's processing export and FDI inflows. Thus, we test these three hypotheses against the Chinese experience when major institutional reforms occurred concurrently with the dramatic expansion of processing trade surrounding China's entry into the WTO.

3.3 Data

The primary data sources are Chinese Urban Household Surveys (CUHS 1992-2006) and the Chinese customs trade data (1992-2008). Both datasets cover mainland China's provinces except Tibet due to data missing in CUHS. The CUHS is conducted by China's National Bureau of Statistics (NBS). It records basic conditions of urban households and provides detailed information of workers' demographic characteristics (age, gender, and marital status), employment (income, educational attainment, working experience, occupation, and industry) and geographic residence (city and province). The survey includes information on about 15,000 to 56,000 workers in a year. In this paper, we focus on annual wages of manufacturing adult workers engaging in wage employment. Wage income consists of basic wage, bonus, subsidies and other labor-related income from regular jobs. We compute the real wage by deflating annual wages to the base year (2006) using province-specific urban consumption price indices.

[12] Please see Branstetter and Lardy (2008) for a detailed discussion of China's policy changes upon the WTO accession.

The trade dataset records both the value and quantity of export at the product level (six-digit HS code), exporter locations and destinations, firm ownership types, and types of Chinese custom regimes. The firm ownership types include Chinese-owned domestic firms, joint ventures, and wholly foreign-owned firms. In this paper, we use the rest of world (ROW) as the North country, but for robustness check we use China's high-income trade partners as the North. Our definition of high-income countries follows the World Bank's standard classification, including 66 countries. [13] China's processing exports to high-income countries contributed about 90 percent of its total processing exports. Most of empirical results hold for both samples. Based on these two datasets, we test three hypotheses in the next section.

4 Empirical Evidence

4.1 Hypothesis I: Skill Intensity Hypothesis

To compare the skill intensity of processing exports across firm ownership types, we first compute the average skill intensity by firm ownership types for the period 1992-2008, as shown in Figure 5. The average skill intensity for the firm ownership type O in year t is defined as

$$\widetilde{z}_t^O = \sum_i (z_i \frac{y_{i,t}^O}{\sum_i y_{i,t}^O}) = \sum_i z_i s_{i,t}^O$$

where $O = F, J, D$. z_i denotes the skill intensity of industry i, and $y_{i,t}^O$ and $s_{i,t}^O$ denote the value and share of processing exports of industry i in year t for the firm ownership type O. Thus, the average skill intensity is a weighted mean of industrial skill intensity, using the industrial share of processing exports $s_{i,t}^O$ as the weights. The average skill intensity for ordinary exports can be computed similarly.

The measure of skill intensity z_i for industry i is defined as the ratio of workers with college degrees or above to industrial total employment. The data is from Chinese National Industry

[13] Taiwan is not included in the World Bank's data, although it qualifies to be a high-income region. We add Taiwan into our sample because it is an important trade partner of mainland China.

Census 1995 (CNIC1995), which reports employment by education at the 3 digit industry level for 1994. [14] We drop the most skill-intensive sector to avoid that our results are impacted by this sector, which is 75 percent higher than the second highest. [15]

Figure 5 presents the evolution of average skill intensity of processing exports by three types of firm ownership verse ordinary exports. Clearly, the average skill intensity is the highest for foreign owned firms, the next highest for joint ventures, followed by Chinese domestic firms, with the lowest being for ordinary exports. Since 1992, there has been significant skill upgrading in the processing exports, especially among foreign owned firms, while the skill upgrading in ordinary trade has been limited.[16] This pattern strongly supports the first hypothesis. However, it can not rule out the possibility that foreign-owned firms are better in both the least and most skill-intensive industries, which makes their average skill intensity higher than other firms. Thus, we look into the distributional differences across firms.

Figure 7 presents the distributions of processing exports by firm ownership types in 1992 and 2008. The empirical distribution $\widehat{G}^O(z)$ for $O = F, J, D$ is constructed as follows:

$$\widehat{G}_t^O(z) = \sum_i I(z_i \leq z) s_{i,t}^O$$

where $I(.)$ is the indicator function. This figure reveals two important messages. First, the distribution of foreign-owned firms is more skewed toward skill-intensive sectors than those of joint venture and Chinese-owned firms. In other words, the distribution of foreign-owned firms first-order stochastically dominates those of other firms. Moreover, this feature is more significant in 2008 than 1992. Second, all distributions shift toward right from 1992 to 2008, implying sig-

[14] The CNIC1995 is based on Chinese Standard Industrial Classification 1994 (CSIC1994) at 3 digits level, which has similar structure as ISIC REV.3 at 4 digits level. So we convert both the skill intensity measure and trade data based on Harmonized system into ISIC REV.3 at 4 digits level. Once we restrain ourselves to manufacturing sector, we cover 113 out of 127 classes in ISIC REV.3 at 4 digits level. Please see the concordance detail in Appendix F.1.

[15] As a robustness check, we use the skill intensity measure from the National Economic Census 2004 (NEC 2004). The correlation of two measures is as high as 0.8, but the second has a higher mean and variance, which magnifies the differences in the skill intensity across industries, and thus the average skill intensity is higher and the gaps between firm ownerships are larger. However, the patterns of skill intensity by firm ownership types in Figure 5 remain the same.

[16] Figure 5 is based on the sample of exports to all countries, but the patterns of skill intensity across firm ownership types and export regimes are the same for the sample of high-income countries.

nificant skill upgrading in the processing exports. Note this feature is also more significant for foreign-owned firms.

More formally, following Delgado et al. (2002) we adopt a non-parametric test for first-order stochastic dominance. Let $G^O(z)$ denote the cumulative distribution of the processing exports by firm ownership O. Then $G^F(z)$ has first-order stochastic dominance over $G^J(z)$ if the following condition holds: $G^F(z) - G^J(z) \leqslant 0$ uniformly in $z \in R$, with strict inequality for some z. Thus, we are interested in testing the following hypotheses.

(i) Two-sided test

$$H_0 : G^F(z) = G^J(z) \text{ for } z \in R \text{ v.s. } H_1 : G^F(z) \neq G^J(z) \text{ for some } z$$

can be rejected.

(ii) One-sided test

$$H_0 : G^F(z) - G^J(z) \ \leq 0 \text{ for } z \in R \text{ v.s. } H_1 : G^F(z) > G^J(z) \text{ for some } z$$

can not be rejected.

The two-sided test tests the equality of two distributions and the one-sided test tests the hypothesis that $G^F(z)$ has weakly first-order stochastic dominance over $G^J(z)$. If the two-sided test is rejected and the one-sided test is not rejected, it indicates that $G^F(z)$ strictly stochastically dominates $G^J(z)$. In other words, the processing exports by foreign-owned firms are more skill intensive than those by joint ventures.

The Kolmogorov–Smirnov test statistics of the two-sided and one-sided tests for two equal numbers of observations are $T_n^1 = \sqrt{n/2} \max |\widehat{G}^F(z) - \widehat{G}^J(z)|$ and $T_n^2 = \sqrt{n/2} \max\{\widehat{G}^F(z) - \widehat{G}^J(z)\}$, respectively, where $\widehat{G}^O(z)$ is the empirical distribution of $G^O(z)$ for $O = F, J$ as constructed above.

The Kolmogorov-Smirnov test requires independent identical sample, while we have sampling data for 1992-2008 and they may have autocorrelations across years. Thus, we run the test year by year. Table 1 presents testing results where 1 denotes rejection of the null hypothesis at 10% significant level, and 0 means a failure to reject the null. The two-sided test for foreign-owned firms and joint ventures (column 1) shows that it rejects the null for years 1998-2008 but not for earlier years, and the one-sided test (column 2) does not reject the null for all years in our sample. Thus, we can conclude that processing exports by foreign-owned firms have been more skill intensive than those by joint ventures since 1998. It is reasonable that the two-sided test fails to reject the null for years before 1998, because the trade cost was high and foreign ownership was restricted, few foreign-owned firms and joint ventures entered. Thus, the distributions of foreign-owned firms and joint ventures are not statistically different from each other. As the trade cost declined and the restrictions on foreign ownership were gradually removed, more intermediate goods were offshored through foreign-owned firms and joint ventures. Thus, their distributional differences became statistically significant.

The testing result is similar for joint ventures and Chinese-owned domestic firms. The two-sided test (column 3) shows that it rejects the null for years 1997-2008, and the one-sided test (column 4) does not reject the null for all years. This implies that processing exports by joint ventures have been more skill intensive than those by Chinese-owned firms since 1996. Because the stochastic dominance is a partial order, we can conclude that processing exports by foreign-owned firms have been more skill intensive than those by Chinese-owned firms since 1997.

This two-step testing procedure can be applied to testing for skill upgrading in processing exports for each type of firms. Table 2 shows the results for each five-year interval during 1992 and 2007. The two-sided test rejects the null but the one-sided test fails to reject the null for all firms in three time regimes. It implies that there is significant skill-upgrading in processing exports for all firms. However, recall the fact that processing exports by foreign-owned firms became more skill intensive than those by joint ventures and Chinese-owned firms after 1998. Thus, it must be the case that the skill upgrading is similar for all firms before 1998, but is more substantial in foreign-owned firms than joint ventures and Chinese-owned firms thereafter.

We also conduct this stochastic dominance test for the sample of China's export to high-income countries. All the results in Table 1 and 2 remain to hold, except that processing exports by joint ventures have been more skill intensive than those by Chinese-owned firms since 1997, rather than 1996.

In the end, we show how much foreign-owned firms can account for the rising skill content in total processing exports. The contribution of each type of firm to the skill content in processing export can be defined as the ratio of the skill content in the processing exports by firm type O to the skill content of the total processing export, i.e.,

$$skshr_t^O = \frac{\sum_i z_i y_{i,t}^O}{\sum_i z_i y_{i,t}} = \frac{\widetilde{z}^O}{\widetilde{z}} \frac{\sum_i y_{i,t}^O}{\sum_i y_{i,t}} = Z^O * VS_t^O$$

where $Z^O = \widetilde{z}^O / \widetilde{z}$ is the relative average skill intensity by firms with ownership O, and $VS_t^O = \frac{\sum_i y_{i,t}^O}{\sum_i y_{i,t}}$ is the value share of processing exports by firms with ownership O. This implies that the role of firms with different ownership types can be decomposed into two parts: the relative average skill intensity and its share in processing export. Notice this decomposition exercise only measures the "between" industrial skill upgrading, but not the "within" industrial skill upgrading.

Figure 8 presents the skill content shares by firm types in processing exports during 1992 and 2008, together with the processing export share of foreign-owned firms. It shows that foreign-owned firms have grown from a minor player in the skill content of processing exports to the dominating organization in 2008, i.e., it contributed about 68 percent of skill content of processing exports.

4.2 Hypothesis II: Distributional Hypothesis

In previous section, we have shown that the processing exports by foreign-owned firms are more skill intensive than other firms, and play the rising role in the skill content of processing exports. Thus, the regional distribution of processing export by foreign-owned firms becomes the important determinants of regional skill demand. In this section, we explore the determinants of the regional distribution of processing export by firm ownership types.

We use the revenue function in Equation (4) to derive the econometric specification for the second hypothesis. By taking the logarithm transformation of the revenue function, we get

$$\ln R = \ln \lambda + \frac{\alpha}{1-\alpha}[-\ln t + z \ln \frac{\beta}{1-\beta} - z \ln \frac{q^S}{w^S} + \ln \alpha + \ln(1-\beta) - \ln w^S] \tag{10}$$

However, it is not the optimal revenue for the Northern innovator and we need to modify it accordingly. The first term in bracket only considers the intensive margin effect of the trade cost, which is the same for three types of firm ownerships, but ignores the extensive margin effect, which is different for firm ownership types, as shown in Lemma (2). Thus, we include the interaction term between firm ownerships and the trade cost variables in regression. Second, the second term in bracket implies the complementarity of skill intensity and the Northern innovator's ex post revenue share. However, it omits the optimal ownership choice and its determinants. Thus, we include the interaction term of firm ownerships and measures of ownership liberalization and contract environment. If Lemma 2, 3 and 4 hold, we would expect that trade costs reduction, ownership liberalization and improvement in contract environment would increase more the processing exports of foreign-owned firms.

Third, the third term in bracket reflects the impact of comparative advantage on export. Following Romalis (2004), and Nunn (2007), we use the share of the high-skilled labor to indicate the relative price of high-skilled labor, and include the interaction term of industrial factor intensity (h_i, k_i) (skill intensity and capital intensity) and factor endowment variable V_{jt} (H_{jt}, K_{jt}). In the end, we use dummy variables for industries, provinces, years and ownerships to control for the demand shift λ, low-skilled labor wage and yearly effect and ownership fixed effect.

To test this hypothesis, we need to obtain measures of ownership liberalization, contract environment and trade costs. For ownership liberalization, we construct a unique measure of ownership liberalization using the official list from the Chinese government that specifies which industries are encouraged, restricted, or prohibited for foreign investment. This list, provided in the Catalogue for the Guidance of Foreign Investment Industries (NDRC, various years), was first published in 1995 and was revised subsequently in 1997, 2002, 2004, and 2007. For encouraged industries, foreign investors have more freedom in choosing their ownership structures, and they enjoy other advantages such as preferable corporate tax rates, low costs of land, and duty-free for imported inputs. In contrast, for restricted or prohibited industries, the Chinese government usually imposes stringent restrictions on ownership structures and high entry cost for foreign investors. The Chinese government removed the restrictions and prohibition for about a half of the industries, which initially was restricted or prohibited, and expanded about 44% of its encouragement coverage after access to the WTO.

For subsequent regression analysis, we construct two proxies for ownership liberalization at the industry level: an encouragement policy indicator and a restriction (includes prohibited) policy indicator. We assign the value of 1 for encouragement (or restriction) policy in an industry if at least one product in that industry is formally stated on the government list of encouragement (or restriction). Otherwise, we assign the value of 0 to that industry. We also assume that there are no policy changes until a formal revision is announced in the published Catalogue. These two policy indicators capture the differences in ownership regulations between industries with and without policy interventions. [17]

For the measurement of contract environment, we follow the literature on the influence of institutional quality on the trade pattern (Nunn, 2007; Levchenko, 2007; Feenstra et al., 2010). These studies use the indexes of doing business in 30 provincial capitals in China published by the World Bank (2008). Specifically, we use a "court cost" variable, which is measured as the ratio of official costs of going through court procedures to the debt claim. Higher "court cost" indicates an inefficient, rent-seeking legal system, implying a lower probability of upholding contracts between firms. For convenience of interpretation, we construct a court efficiency measure, which equals 0.5 minus the ratio of court cost, as in Feenstra et al. (2010). [18] The spatial differences in court

[17] Please see Sheng and Yang (2011) for the details about our construction method.

[18] World Bank (2008) also provides two other measures of contract environment: "court time", which measures the

efficiency in China are substantial. The Southeast coastal provinces usually have higher levels of court efficiency than do interior and northern provinces.

To approximate trade costs, we use the cumulative number of national policy zones that had been opened up to a year in a specific province.[19] China began to establish special economic zones for export in the early 1980 in coastal cities. Owing to their initial success, special zones were expanded into inland cities (Wang, 2010). These policy zones include Economic and Technological Development Zone, High-Tech Development Area, Bonded Area, Export Processing Zone, and other types. Multinational companies in these zones enjoy various advantages, including lowered corporate tax rate of 15 percent, duty free for imported inputs, no import quotas, low costs of land, and no property tax in the first five years. There are also additional benefits for foreign firms if they export most of their products. The data reveal two booming periods of policy zones: the first is 1990-1993 when the cumulative number of zones jumped from 18 to 130, and the second is 1999-2003 when the number increased from 139 to 196. By 2006, a total of 221 policy zones had been established in China. Their existence has reduced the costs of international trade. To avoid the potential contemporaneous correlations between provincial variables with the error term, we use one-year lagged values of trade costs measures and those of factor endowment as the benchmark specification.

To develop the regression specification, we denote our dependent variable $ln(R_{oijt})$ as the log value of processing exports value of ownership o, in industry i, province j, and year t. Indicator variables for three types of ownerships are denoted by a vector D_{oijt}. We interact D_{oijt} with ownership encouragement policy, denote EP_{it}, ownership restriction policy, denote RP_{it}, contract

time interval between the time the plaintiff files the lawsuit and the time of payment, and "court rank" of the court system in each provincial capital based on the measures of "court cost" and "court time". As Nathan Nunn points out in Feenstra et al. (2010), either a very short period of time or a very long period of time can be an indicator of inefficient legal system; as such, there is no monotonic relationship between court time and court efficiency. We also agree with this point; thus, we use the court cost as a measure of judicial efficiency in our study.

[19]We adopt this measure rather than tariff because of two reasons. First, all imports for processing exports are duty-free in China, and outward export tariffs do not have variations across provinces. Second, the setup of national policy zones requires authorization from the central government, which can be arguably considered as an exogenous process beyond the control of provincial governments. Therefore, the endogeneity problem is not a major concern.

environment, denote Q_j, and with trade cost variable, denote TC_{jt}, obtaining the regression:

$$ln(R_{oijt}) = \theta_1' D_{oijt} + \theta_2' D_{oijt} EP_{it} + \theta_3' D_{oijt} RP_{it} + \theta_4' D_{oijt} Q_j + \theta_5' D_{oijt} TC_{jt} \tag{11}$$
$$+ \varsigma' \varpi_i V_{jt} + \xi_i + \xi_j + \xi_t + \epsilon_{oijt}$$

Where ξ_i, ξ_j and ξ_t are the indicator variables of industry, province and year. Note the trade liberalization measure differs across provinces and years, the ownership liberalization policy differs across industries and years. However, the contract environment only differs across provinces, as discussed in detail as below, thus these interactions are collinear with provincial dummy. Therefore, the interaction between Chinese-owned firm and contract environment variable is treated as omitted group.

We begin a simple specification in Table 3 that only includes the interaction terms of ownerships with key variables of ownership liberalization policy, contract environment and the trade cost, and dummies for ownership, province, industry and year. For brevity we do not report coefficients for dummies variables. The second column presents the OLS results with controls for the interaction terms of factor intensities and factor endowments. Both OLS regressions show that the ownership policy, contract environment and the trade cost have significant effect on the export of joint ventures and foreign-owned firms. Consistent with our model prediction, their effects on foreign-owned firms are larger than joint ventures and Chinese-owned domestic firms.

As Lu et al. (2008) and Feenstra et al. (2010) point out, the contract environment variable (Q_j) is likely to be endogenous to trade volume. We follow their practice of using former colonial rule, i.e., by British, France, Russia, or a combination of multiple powers, as well as provincial population in 1953 as instruments for contract environment. We report the IV results using GMM, and test for weak instruments using an F-test in the first-stage regression, as recommended by Stock et al. (2002). The F-test statistics are all above the Stock-Yogo criteria of 10, rejecting the notion of weak instruments.

The IV result in column (3) confirms our finding with the OLS regression, and strongly supports our second hypothesis. The encouragement policy raises the export of foreign-owned firms and joint ventures by $exp(0.44) - 1 = 55$ percent and $exp(0.18) - 1 = 20$ percent, respectively, compared with those firms in industries without preferable policy. By contrast, the restriction policy significantly reduces the export of foreign-owned firms and joint ventures by $1-exp(-0.458) = 37$ percent and $1 - exp(-0.134) = 13$ percent. The IV estimate of court efficiency also supports our second hypothesis. Consider the inner province Sichuan and the coastal province Shanghai, if Sichuan had the same efficient court system as Shanghai, ceteris paribus, the processing export of foreign-owned firms and joint ventures will increase by $exp(3.93 * (26.65\% - 8.99\%)) = 2$ times and 1.7 times, respectively. The establishment of national policy zones also has significantly positive effects on the processing trade. Opening one additional national policy zone is associated with 12 percent and 3 percent increase in the export of foreign-owned firms and joint ventures, respectively. However, it does not have significant effect on the export of Chinese-owned domestic firms. These results are consistent with model predictions that trade and ownership liberalization and improvement in contract environment will increase the export of foreign-owned firms more than firms, when three types of firm ownership coexist. [20]

This specification omits reductions in other unobservable or unmeasured trade costs around China's access to the WTO. We expect the impact of ownership liberalization and contract environment would have more significant effect after China entered the WTO. Thus, we run the IV regression after 2001, and the result is shown in column (4) of Table 3. We find that the effects of encouragement policy and contract environment are much stronger after 2001, while the negative effect of restriction policy on foreign firms decreases. The effect of trade costs captured by the cumulative number of zones becomes slightly smaller for foreign firms. This is reasonable because the average area of national policy zones decreased from 110 to 62 square kilometers as the

[20] We also conduct various sensitivity analysis, including using province-year pair dummy, alternative measure of the trade cost and contract environment variables. Following Limão and Venables (2001), the alternative measure of the trade cost is infrastructure, measured as the log value of the miles of railways and highways, relative to the minimum distance to two major ports: Shanghai and Hong Kong. World Bank (2008) also provides two additional measures of business environment: (1) the official cost of starting a commercial or industrial firm, as a percentage of income per capita, so called "startup cost"; (2) the official cost of involving in registering property, as a percentage of property value, so called "registration cost". These two variables may capture the cost of acquiring legal protection for business. We find that all the major results are robust to these alternative specifications.

number of zones increased from 1990s to 2000s. One noticeable difference is that the estimated coefficients of encouragement policy and trade cost reduction for Chinese firms are also positive. However, this result is hardly surprising because the industries targeted by the government encouragement policies are also likely to receive other preferential treatments, have reduced bureaucratic barriers, and encounter lower entry costs for all types of firms, thus leading to expansion in the processing trade by indigenous Chinese firms. As a result of ownership liberalization, positive productivity spillover to Chinese firms by the growing presence of multinational companies may also promote the export of Chinese firms (Chen and Swenson, 2007).

In the end, Table 4 presents the estimation results based on the sample of high-income countries, and all results are broadly consistent with our benchmark findings. Moreover, the effect of ownership policy and contract environment are even stronger for this narrowly defined North country.

4.3 Hypothesis III: College Premium Hypothesis

In this section we explore the effect of the regional distribution of processing export by firm ownership types on the regional skill premium. The empirical specification follows the classical Mincer earning regression, which models the log value of real earning as a function of workers' education and years of potential labor market experience. Thus, the dependent variable for analysis, $\ln(w_{mjt})$, is the log value of real annual wage for individual m in province j and year t. We use college indicator ($coll_{mjt}$) as the basic measure of education since we care about the college premium. The local labor market may rewards college workers differently due to their differential exposure to globalization and other factors. Thus, we interact the college indicator with these key provincial variables, including processing exports/GDP ratio, denoted as $proexratio_{jt}$, the processing exports share of foreign-owned firms and joint ventures, denoted $feshr_{jt}$ and $jvshr_{jt}$.

Thus, the basic estimation equation is

$$ln(w_{mjt}) = \alpha_0 + [\beta_0 + \beta_1 proexratio_{jt} + \beta_2 feshr_{jt} + \beta_3 jvshr_{jt} + \beta_4 X_{jt}] \times coll_{mjt} + \gamma G_{mjt} + \delta_{jt} + \epsilon_{mjt} \quad (12)$$

where X_{jt} are other provincial variables associated with the college premium. G_{mjt} are other personal characteristics including gender, experience, experience squared and the indicator of state owned sector. δ_{jt} are province-year pair dummy to control for province-year varying effect. Province-year cluster robust standard deviation is adopted to control for the sample dependence in CUHS. Our theory suggests that regions that have more processing exports and higher share of foreign-owned firms have higher skill demand and thus higher college premium, thus we would expect β_1 and β_2 are positive.

Table 5 column (1) begins with a simple specification without any interaction terms with college indicator. It shows that on average the college workers earned about 35 percent more than non-college workers, and one additional year of experience is associated with a 4.8 percent increase in real wage. In addition, female earns less than male, and workers in the state sector earn about 20 percent more. These results are consistent with existing literature (Zhang et al., 2005; Ge and Yang, 2009). Next we include the interaction terms of college indicator with the processing export/GDP ratio and the share of foreign-owned firms. Column (2) shows that both processing exports size and the share of foreign-owned firms are important for the college premium.

However, this regression does not control for alternative theories of the college premium. Two popular alternatives are skill-biased technology hypothesis (Acemoglu, 1998, 2003) and the capital-skill complementarity hypothesis (Krusell et al., 2000). We use the ratio of R&D expenditure to output to capture the domestic skilled-biased technology, and the import share of equipment and FDI as a percentage of investment to capture the imported skilled biased technology, following Eaton and Kortum (2001); Burstein et al. (2011). Capital-to-output ratio is used to capture capital-skill complementarity. As a comparison of processing exports, the ratio of ordinary export to GDP is also included.

Column (3) presents our benchmark result with these additional controls. Our key variable, the processing exports share of foreign-owned firms, is robust. The effect of processing exports becomes larger and the role of joint venture become insignificant. One percentage point increase in processing exports size and the share of foreign-owned firms are associated with about 0.77 and 0.24 percentage point increase in the college premium, respectively. Moreover, both alternative theories are not supported by the data. The R&D expenditure, import of equipment and capital-to-output ratio are all not significant. The negative sign of FDI may indicate the role of horizontal FDI because the share of foreign owned and joint venture in processing exports contain information of vertical FDI. Note the role of ordinary export has a positive effect on the college wages, but its magnitude is only 40 percent of processing exports. Overall, our theory is the most possible explanation for the rising college premium in China. [21]

One caveat of these regressions is that processing exports may be endogenous to labor market outcomes. For example, firms that export processing goods tend to choose regions with abundant high-skilled labors if their intermediate goods are more skill intensive. Next, following Frankel and Romer (1999), we adopt a two-stage procedure to deal with this issue. First, we construct the predicted values of processing exports ratio, and the processing exports shares of foreign-owned firms and joint ventures in processing exports from the regression in Hypothesis II (regression (11)) as follows:

$$proexratio\_pred_{jt} = \sum_{i,o} exp(\widehat{lnR}_{oijt})/GDP_{jt}$$

$$feshr\_pred_{jt} = \sum_{i,o=F} exp(\widehat{lnR}_{oijt})/\sum_{i,o} exp(\widehat{lnR}_{oijt})$$

$$jvshr\_pred_{jt} = \sum_{i,o=J} exp(\widehat{lnR}_{oikt})/\sum_{i,o} exp(\widehat{lnR}_{oijt})$$

where $\widehat{lnR}_{oijt}$ is the predicted log value of processing exports from the regression (11), based on

[21]This result is robust if we adopt a two-step regression, in which we first run Mincer regression for each province at each year, and get a province panel of estimates of college premia, and then regress the imputed college premium on these provincial variables in Table 5.

the result in column (3) of Table 3. Second, we use these predicted variables as the instruments of endogenous variables in the Mincer regression.

Table 5 column (4)-(5) report the result of using the predicted values as instruments. [22] Compared with OLS results, the role of processing exports is stable while the effect of the export share of foreign owned decreases. One possible reason is that the regression (11) has more explanation power in the size of processing exports than in the export differentials across firm ownership types. One way to reduce the noise in the regression (11) is to focus on the export to high-income countries. As we show in Table 4, the effect of ownership policy and contract environment are stronger for this narrowly defined North country. Table 6 shows the results when we use the sample of high-income countries. The OLS results in column (1)-(3) are largely consistent with our baseline results. Moreover, the instrument results in column (4) and (5) show that the export shares of foreign-owned firms are significantly positive. The impact of joint ventures becomes negatively significant in all IV specifications because the rising share of foreign-owned firms is more likely to crowd out export by joint ventures, which may create the negative statistical correlation.

In the end, for robustness check, we use the schooling years to take the place of the college indicator. Table 7 shows that the results are largely consistent with our baseline findings. Notice we need to multiple the coefficients by a factor of 4, when we compare the effect on college premium and return to education. Thus, the effect of processing exports size on return to schooling are consistently higher across different specifications and samples than its effect on college premium. However, the role of the share of foreign-owned firms is consistently with its effect on the college premium.

5 Conclusion

This paper proposes a new mechanism linking trade and wage inequality in China: ownership liberalization due to China's accession to WTO in 2001. It has offered robust evidence that the

[22] The two-stage least square procedure leads to a wrong estimate of standard deviation of the coefficients in the second stage. We need to correct the standard deviations using bootstrap method.

processing exports of foreign-owned firms are more skill intensive than these of joint ventures and Chinese-owned firms. A reduction in trade costs, ownership liberalization, and improvement in the contract environment increase more processing exports by foreign-owned firms, which eventually rises the relative demand of high-skilled labor. The Mincer regression has also showed that the size of processing exports and the share of foreign-owned firms are both important determinants of the college premium between 1992 and 2006. This finding does not appear to be explained by any of a variety of alternative hypotheses.

These findings have important policy implications for developing countries. Conventional wisdom might suggest that developing countries encourage joint ownership between the South and the North, in hopes of greater spillover from the North through joint ventures. Our analysis implies that the multinationals jointly decide their strategies for offshoring, ownership and skill demand. Thus, if the South imposes foreign ownership restrictions, more skill-intensive products remain in the North, and only less skill-intensive products are offshored to the South. In the end, this lowers the demand for high-skilled labor, and therefore impedes the economic growth in the South.

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Appendices

A Proof of Lemma 2

Since $S(z,\beta)$ is continuous and differentiable function, we only need to show $\frac{\partial^2 S(z,\beta)}{\partial z \partial \beta} > 0$ for supermodularity, according to Milgrom and Roberts (1990) and Topkis (1998). To show $\frac{\partial^2 S(z,\beta)}{\partial z \partial \beta} > 0$, we only need to show that

$$\frac{1}{\beta(1-\beta)} > \frac{(1-\alpha)(2-\alpha)}{[1-\alpha(1-\beta)+\alpha(1-2\beta)z]^2} \tag{A.1}$$

For $\beta \in [1/2, 1]$, the RHS of inequality (A.1) increases in z. So we only need to show that the inequality holds for $z = 1$, which is

$$[1-\alpha\beta]^2 > \beta(1-\beta)(1-\alpha)(2-\alpha)$$

For $\beta \in [0, 1/2]$, the RHS of this inequality decreases in z. So we only need to show that the inequality holds for $z = 0$, which is

$$[1-\alpha(1-\beta)]^2 > \beta(1-\beta)(1-\alpha)(2-\alpha)$$

It is easy to see that the second inequality is the same as the first one if we redefine $\hat{\beta} = 1-\beta$. So we only need to prove the inequality for $\beta \in [0, 1/2]$. . This inequality can be shown by proving it in two cases where $\alpha < 2/3$ and $\alpha \geq 2/3$. For $\alpha < 2/3$, it is easy to show that

$$(1-\alpha\beta)^2 \geq (1-\alpha)^2 > (1-\alpha)(2-\alpha)/4 \geq \beta(1-\beta)(1-\alpha)(2-\alpha)$$

For $\alpha \geq 2/3$, we can use convexity property of functions. Clearly $g(\beta_1) = (1-\alpha\beta)^2$ is a convex function on a compact interval, so we have

$$\begin{aligned} g(\beta) &\geq g(1) + g'(1)(\beta-1) = (1-\alpha)^2 + (1-\alpha)(3\alpha-2)(1-\beta) + (2-\alpha)(1-\alpha)(1-\beta) \\ &> 0 + (2-\alpha)(1-\alpha)(1-\beta)\beta \end{aligned}$$

Next step we show $S(z,\beta)$ is concave in z and strictly concave in β.

$$\frac{\partial^2 S(z,\beta)}{\partial z^2} = -\frac{\alpha(1-\alpha)(1-2\beta)^2}{[1-\alpha\beta z-\alpha(1-\beta)(1-z)]^2} \leqslant 0$$

and

$$\frac{\partial^2 S(z,\beta)}{\partial \beta^2} = -\frac{(\beta-z)^2 + z(1-z)}{\beta(1-\beta)} - \frac{\alpha(1-\alpha)(1-2z)^2}{[1-\alpha\beta z-\alpha(1-\beta)(1-z)]^2} < 0$$

Because $S(z,\beta)$ is continuous and strictly concave in a compact set of $\beta \in [0,1]$, there must be a unique maximizer $\beta^*(z)$ for a given value of z, according to the maximum theory. Moreover, by the Topkis's theorem, the supermodularity implies $\beta^*(z)$ increases in z. Here we show it by using the implicit function theory.

The first order condition for β is $S_\beta(\beta^*(z), z) = 0$ for an inner solution, differentiating the first order condition, with respect to z and using the implicit function theorem, we find that $\frac{\partial \beta^*(z)}{\partial z} = -\frac{S_{\beta z}(\beta^*(z),z)}{S_{\beta\beta}(\beta^*(z),z)} > 0$. For conner solution, we have $\beta^*(0) = 0$ and $\beta^*(1) = 1$, so our statement of $\beta^*(z)$ still holds.

B Proof for lemma 3

To show Lemma 3, we first show the following corollary.

Corollary 1

(a) For $\beta = 1/2, \frac{\partial S(z,\beta)}{\partial z} = 0$ and $S(z, 1/2) < 0$. This implies that the log profit ratio of joint ventures is independent of z.

(b) For $\beta > 1/2, \frac{\partial S(z,\beta)}{\partial z} > 0$, $S(z = 0, \beta) < S(z = 0, 1/2) < S(z = 1, 1/2) < S(z = 1, \beta) \leqslant 0$. Since $\beta^F > 1/2$, this implies that the log profit ratio of foreign-owned firms increases in z. Moreover, there exists a unique $z^*_{JF} \in (1/2, 1]$, such that $S(z^*_{JF}, \beta^F) = S(z^*_{JF}, \beta^J)$, $S(z, \beta^F) > S(z, \beta^J)$ if $z > z^*_{JF}$, and $S(z, \beta^F) < S(z, \beta^J)$ if $z < z^*_{JF}$.

(c) For $\beta < 1/2, \frac{\partial S(z,\beta)}{\partial z} < 0$, $S(z = 1, \beta < 1/2) < S(z, 1/2) < S(z = 0, \beta < 1/2) \leqslant 0$. Since $\beta^D < 1/2$, this implies that the log profit ratio of Southern-owned firms decreases in z. Moreover, there exists a unique $z^*_{DJ} \in [0, 1/2)$, such that $S(z^*_{DJ}, \beta^D) = S(z^*_{DJ}, \beta^J)$, and $S(z, \beta^D) > S(z, \beta^J)$ if $z < z^*_{DJ}$, and $S(z, \beta^D) < S(z, \beta^J)$ if $z > z^*_{DJ}$.

Proof. For (a), evaluating $S(z,\beta)$ and its derivative of z at $\beta = 1/2$ shows that $S(z, 1/2) = \frac{1-\alpha}{\alpha}[\ln(1 - \frac{\alpha}{2}) - \ln(1 - \alpha)] - \ln 2 < 0$ and $\frac{\partial S(z,\beta)}{\partial z}|_{\beta=1/2} = 0$.

For (b) and (c), since $S(z,\beta)$ is supermodular, we have $\frac{\partial S(z,\beta)}{\partial z \partial \beta} > 0$, then

$$\frac{\partial S(z,\beta)}{\partial z}|_{\beta>1/2} > \frac{\partial S(z,\beta)}{\partial z}|_{\beta=1/2} = 0 > \frac{\partial S(z,\beta)}{\partial z}|_{\beta<1/2}$$

Thus $S(z,\beta)$ has a positive slope in the direction of z when $\beta > 1/2$, while negative when $\beta < 1/2$. Moreover, since $f(x) = \ln x + \frac{1-\alpha}{\alpha}[\ln(1 - \alpha x) - ln(1 - \alpha)]$ increases in x if $x \in (0, 1)$, so $f(x) \leq 0$ and the equality holds only if $x = 1$. Thus $S(z = 0, \beta) = \ln(1 - \beta) + \frac{1-\alpha}{\alpha}[\ln(1 - \alpha(1 - \beta)) - ln(1 - \alpha)] \leq 0$ and $S(z = 1, \beta) = \ln \beta + \frac{1-\alpha}{\alpha}[\ln(1 - \alpha\beta) - ln(1 - \alpha)] \leq 0$. Also we can see $S(z = 0, \beta)$ decreases in β and $S(z = 1, \beta)$ increases in β.

Therefore, for $\beta > 1/2$, $S(z=0,\beta) < S(z=0,1/2) = S(z,1/2)$, and $S(z=1,\beta) > S(z=1,1/2) = S(z,1/2)$. The profit ratio for $\beta > 1/2$ increases in z, and with one corner value less than the profit ratio of joint venture, and the other larger than profit ratio of joint venture. Thus two profit ratio curves only has single crossing. Let z^*_{JF} denote the crossing point, then for $z > z^*_{JF}$, we must have $S(z,\beta > 1/2) > S(z^*_1, \beta > 1/2) = S(z^*_1, 1/2) = S(z,1/2)$, or $S(z,\beta^F) > S(z,\beta^J)$. Similarly, we can show that $S(z,\beta^F) < S(z,\beta^J)$ for $z < z^*_{JF}$.

It is similar to show the case for $\beta < 1/2$. We can get $S(z=0,\beta) > S(z=0,1/2) = S(z,1/2)$, and $S(z=1,\beta)$ $< S(z=1,1/2) = S(z,1/2)$. Since the profit ratio for $\beta < 1/2$ decreases in z, there must have single crossing between the profit ratios for $\beta < 1/2$ and joint venture. Let z^*_{DJ} denote the crossing point, then for $z < z^*_{DJ}$, we must have $S(z,\beta < 1/2) > S(z^*_{DJ},\beta < 1/2) = S(z^*_{DJ},1/2) = S(z,1/2)$, or $S(z,\beta^D) > S(z,\beta^J)$. Similarly, we can show that $S(z,\beta^D) < S(z,\beta^J)$ for $z > z^*_{DJ}$.

In the end, we show $z^*_{JF} \in (1/2,1]$ and $z^*_{DJ} \in [0,1/2)$. It is easy to show the unique maximizer for $z = 1/2$ is $\beta^*(z) = 1/2$, by checking the first order condition of $S_\beta(\beta^*(z),z) = 0$ at $z = 1/2$. So if $z^*_{JF} \in [0,1/2]$, then by lemma 3(b), $S(z=1/2,\beta > 1/2) \geq S(z^*_{JF},\beta > 1/2) = S(z^*_{JF},\beta = 1/2) = S(z=1/2,\beta=1/2)$, this implies that for $z = 1/2$, $\beta > 1/2$ is as good as $\beta = 1/2$ in maximizing the profit ratio, which contradicts the fact that $\beta^*(z) = 1/2$ is the unique maximizer for $z = 1/2$. Thus $z^*_{JF} \in (1/2,1]$. By the same spirit, we can show $z^*_{DJ} \in [0,1/2)$.

Based on this corollary, the proof lemma 3 follows naturally. It is easy to show that for $z < z^*_{DJ}$, $S(z,\beta^D) > S(z,\beta^J) > S(z,\beta^F)$ and for $z^*_{DJ} \leq z \leq z^*_{JF}$, $S(z,\beta^J) \geq \max\{S(z,\beta^D), S(z,\beta^F)\}$, and for $z > z^*_{JF}$, $S(z,\beta^F) > S(z,\beta^J) > S(z,\beta^D)$.

C Proof of Proposition 1

First we define

$$B(z,\beta,t) \equiv [N(z) - S(z,\beta)]/z = \ln\frac{(1-\beta)\omega_l}{\beta\omega_h} + \frac{1}{z}[\ln\frac{t}{(1-\beta)\omega_l} + \frac{1-\alpha}{\alpha}\ln\frac{1-\alpha}{1-\alpha\beta z - \alpha(1-\beta)(1-z)}]$$

Thus, $N(z) > S(z,\beta)$ is equivalent to $B(z,\beta,t) > 0$, and vise versa. Based on Assumption 2, we can show the following corollary.

Corollary 2

(1) If Assumption 2 holds, for a given value $\beta < \widetilde{\beta}$*, we have* $\lim_{z\to 0} B(z,\beta,t) < 0$*,* $B(1,\beta,t) > 0$*, and* $B_z(z,\beta,t) > 0$*. Thus, there exists a unique threshold* $z^*(t,\beta) \in (0,1)$ *such that* $B(\beta, z^*(t,\beta), t) = 0$*. As a result, the more skill-intensive intermediate goods (*$z > z^*(t,\beta)$*) are produced in the North. and less*

skill-intensive intermediate goods ($z < z^*(t,\beta)$) are produced in the South.

(2) The cutoff $z^*(t,\beta)$ increases as the trade cost t decreases.

Proof. $\lim_{z\to 0} B(z,\beta,t) < 0$ holds only if the term in the bracket is negative, which is true under the Assumption 2(2). Moreover,

$$B(1,\beta,t) = \ln\frac{t}{\beta\omega_h} + \frac{1-\alpha}{\alpha}\ln\frac{1-\alpha}{1-\alpha\beta} = \ln\frac{t}{\omega_h} + [\frac{1-\alpha}{\alpha}\ln\frac{1-\alpha}{1-\alpha\beta} - \ln\beta] > 0$$

due to the facts that $t > \omega_h$ and the term in the bracket decreases in β and has a minimum at zero.

To show $B_z(\beta,z,t) > 0$, we only need to show

$$r(z,\beta) = \frac{1-\alpha}{\alpha}[\ln(1-\alpha) - \ln(1-\alpha\beta z - \alpha(1-\beta)(1-z))] + \ln(t/(1-\beta)\omega_l) + \frac{z(1-2\beta)(1-\alpha)}{1-\alpha\beta z - \alpha(1-\beta)(1-z)} < 0$$

It is easy to show that $r(z,\beta)$ is non-increasing in z, so $r(z,\beta) \le r(0,\beta) = \ln(\frac{t}{(1-\beta)\omega_l}(\frac{1-\alpha}{1-\alpha(1-\beta)})^{\frac{1-\alpha}{\alpha}})$. Since $r(0,\beta)$ is strictly increasing in β if $\beta > 0$, then $r(0,\beta) < r(0,\widetilde{\beta}) = 0$ for $\beta < \widetilde{\beta}$. The last strict inequality holds due to Assumption 2(2). Thus $B(\beta,z,t)$ is an increasing and continuous function of z, and $B(\beta,1,t) > 0$, $\underset{z\to 0}{lim} B(\beta,z,t) < 0$. Clearly there must be a unique cutoff $z^*(t,\beta) \in (0,1)$ such that $B(\beta,z^*(t,\beta),t) = 0$. Total differentiate with respective to β, z and t at $z^*(t,\beta)$, we get $B_\beta d\beta + B_z dz + B_t dt = 0$ Since $B_t > 0$ and $B_z > 0$, $d\beta = 0$, we have $\frac{dz^*(t,\beta)}{dt} = -\frac{B_t}{B_z} > 0$

Since $\beta^D < \beta^J < \beta^F$, there exists at most three different cutoffs $z^*_{ON}(t) \in (0,1)$, for $O = F,J,D$. The above lemma implies that the most skill-intensive intermediate goods are produced in the North, i.e. for any $z > \max\{z^*_{DN}(t), z^*_{JN}(t), z^*_{FN}(t)\}$, and $\pi(z) = \pi^N(z)$. Moreover, it is easy to show that the order of $z^*_{FN}(t), z^*_{JN}(t), z^*_{DN}(t)$ must be one of the four cases: (1) $z^*_{FN}(t) > z^*_{JN}(t) > z^*_{DN}(t)$; (2) $z^*_{JN}(t) \ge z^*_{FN}(t) \ge z^*_{DN}(t)$; (3) $z^*_{JN}(t) \ge z^*_{DN}(t) > z^*_{FN}(t)$; (4) $z^*_{DN}(t) > z^*_{JN}(t) > z^*_{FN}(t)$. In the first case, four production modes coexists; in the second and third case, the North foreign ownership ($O = F$) will not be optimal for any product z; in the last case, the North foreign ownership or joint venture ($O = F,J$) will not be optimal for any product z. Moreover, the first case also implies $z^*_{FN}(t) > z^*_{JF}$. Because if $z^*_{FN}(t) \le z^*_{JF}$, then $z^*_{JN}(t) \ge z^*_{FN}(t)$ which is contradictory to the first case.

Thus, in the case of four production modes coexist, the most skill-intensive intermediate goods $z > z^*_{FN}(t)$ remain in the North, and the less skill-intensive goods are offshored to the South. Based on Lemma 3, among these products offshored to the South, the more skill-intensive are through North owned foreign firms ($z^*_{FN}(t) > z > z^*_{JF}$), the less skill-intensive are through joint ventures ($z^*_{DJ} \le z \le z^*_{JF}$), and the least skill-intensive are outsourced to Southern-owned firms ($z < z^*_{DJ}$). Thus, there exists a unique triple ($z^*_{FN}(t), z^*_{JF}, z^*_{DJ}$), which indicates the boundary of four production modes. Moreover, as the trade cost t decreases, $z^*_{FN}(t)$ increases.

D Proof for Proposition 2

If three ownership types of firms coexist, we must have $z_{DJ}^* < z_{JF}^* < z_{FN}^*(t)$. Thus, the revenue share of foreign firms in process export is given by

$$\Upsilon^F(t) = \frac{\int_{z_{JF}^*}^{z_{FN}^*(t)} R(z,\beta^F)dF(z)}{\int_0^{z_{DJ}^*} R(z,\beta^D)dF(z) + \int_{z_{DJ}^*}^{z_{JF}^*} R(z,\beta^J)dF(z) + \int_{z_{JF}^*}^{z_{FN}^*(t)} R(z,\beta^F)dF(z)}$$

where $F(z)$ is the distribution of intermediate goods z. Let $\widetilde{R}(z,\beta) = R/(\frac{1}{t})^{\alpha/(1-\alpha)}$, and we can see the above equality holds if we replace $R(z,\beta)$ with $\widetilde{R}(z,\beta)$, but now the trade cost t affects the revenue share of foreign firms only through the extensive margin, i.e. cutoff $z_{FN}^*(t)$. This is because the intensive margin has the same effect on all intermediate goods. It is easy to show that the share of foreign firms increases as $z_{FN}^*(t)$, and we know $z_{FN}^*(t)$ increases as the trade cost t decreases. Thus a reduction in the trade cost increases the revenue share of foreign firms in process export.

E Proof of Proposition 7

We choose a uniform distribution of intermediate goods to simplify the proof. First we show $D_1 < D_2$.

$$\begin{aligned}
D_2 - D_1 \sim & \left(\int_{\Omega_D} h(z,\beta^D)dz + \int_{\Omega_{J,F}} h(z,\beta^J)dz\right)\left(\int_{\Omega} l(z,\beta^D)dz\right) \\
& - \left(\int_{\Omega} h(z,\beta^D)dz\right)\left(\int_{\Omega_D} l(z,\beta^D)dz + \int_{\Omega_{J,F}} l(z,\beta^J)dz\right) \\
& = \left(\int_{\Omega_D} h(z,\beta^D)dz + \int_{\Omega_{J,F}} h(z,\beta^J)dz\right)\left(\int_{\Omega_D} l(z,\beta^D)dz + \int_{\Omega_{J,F}} l(z,\beta^D)dz\right) \\
& - \left(\int_{\Omega_D} h(z,\beta^D)dz + \int_{\Omega_{J,F}} h(z,\beta^D)dz\right)\left(\int_{\Omega_D} l(z,\beta^D)dz + \int_{\Omega_{J,F}} l(z,\beta^J)dz\right) \\
& = \left[\int_{\Omega_D} l(z,\beta^D)dz \left(\int_{\Omega_{J,F}} h(z,\beta^J) - h(z,\beta^D)dz\right) - \int_{\Omega_D} h(z,\beta^D)dz \left(\int_{\Omega_{J,F}} l(z,\beta^J) - l(z,\beta^D)dz\right)\right] \\
& + \int_{\Omega_{J,F}} l(z,\beta^D)dz \int_{\Omega_{J,F}} h(z,\beta^J)dz - \int_{\Omega_{J,F}} h(z,\beta^D)dz \int_{\Omega_{J,F}} l(z,\beta^J)dz
\end{aligned}$$

The term in bracket is

$$
\begin{aligned}
&= \int_{\Omega_D} l(y,\beta^D)dy \left(\int_{\Omega_{J,F}} h(z,\beta^J) - h(z,\beta^D)dz \right) - \int_{\Omega_D} h(y,\beta^D)dy \left(\int_{\Omega_{J,F}} l(z,\beta^J) - l(z,\beta^D)dz \right) \\
&= \int_{y\in\Omega_D} \int_{z\in\Omega_{J,F}} l(y,\beta^D)(h(z,\beta^J) - h(z,\beta^D)) - h(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D))dzdy \\
&= \int_{y\in\Omega_D} \int_{z\in\Omega_{J,F}} h(z,\beta^D)l(y,\beta^D)(h(z,\beta^J)/h(z,\beta^D) - 1) - h(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D))dzdy \\
&> \int_{y\in\Omega_D} \int_{z\in\Omega_{J,F}} h(z,\beta^D)l(y,\beta^D)(l(z,\beta^J)/l(z,\beta^D) - 1) - h(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D))dzdy \\
&= \int_{y\in\Omega_D} \int_{z\in\Omega_{J,F}} \frac{h(z,\beta^D)}{l(z,\beta^D)} l(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D)) - h(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D))dzdy \\
&\geqslant \int_{y\in\Omega_D} \int_{z\in\Omega_{J,F}} h(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D)) - h(y,\beta^D)(l(z,\beta^J) - l(z,\beta^D))dzdy \\
&= 0
\end{aligned}
$$

The first inequality is because $h(z,\beta^J)/l(z,\beta^J) > h(z,\beta^D)/l(z,\beta^D)$, and the second is because $h(z,\beta^D)/l(z,\beta^D) \geqslant h(y,\beta^D)/l(y,\beta^D)$, for $z \geqslant y$. For the second term in $(D_2 - D_1)$, we only need to show

$$
\frac{\int_{\Omega_{J,F}} h(z,\beta^J)dz}{\int_{\Omega_{J,F}} l(z,\beta^J)dz} \geqslant \frac{\int_{\Omega_{J,F}} h(z,\beta^D)dz}{\int_{\Omega_{2,3}} l(z,\beta^D)dz} \tag{E.1}
$$

For this inequality it is sufficient to show $h(z,\beta^J) \geqslant h(z,\beta^D)$, and $l(z,\beta^D) \geqslant l(z,\beta^J)$ for $z \in \Omega_{J,F}$.

$$
\begin{aligned}
\frac{h(z,\beta^J)}{h(z,\beta^D)} &= \frac{\alpha\beta^J zR(z,\beta^J)/q}{\alpha\beta^D zR(z,\beta^D)/q} = \frac{\beta^J\pi(z,\beta^J)/[1-\alpha\beta^J z - \alpha(1-\beta^J)(1-z)]}{\beta^D\pi(z,\beta^D)/[1-\alpha\beta^D z - \alpha(1-\beta^D)(1-z)]} \\
&\geqslant \frac{[1-\alpha\beta^D z - \alpha(1-\beta^D)(1-z)]}{\beta^D} \frac{1}{[2-\alpha]}
\end{aligned}
$$

The inequality holds because $\pi(z,\beta^J) \geqslant \pi(z,\beta^D)$ for $z \in \Omega_{J,F}$. Thus we only need to show $f(z) > [2-\alpha]$, where $f(z) = \frac{[1-\alpha\beta^D z-\alpha(1-\beta^D)(1-z)]}{\beta^D}$. It is easy to show that $f'_z(z) = \frac{\alpha(1-2\beta^D)}{\beta^D} > 0$ due to the fact that $\beta^D < 1/2$. Thus for $z \in \Omega_{J,F}$, $f(z) > f(0) = \frac{1-\alpha(1-\beta^D)}{\beta^D} > 2-\alpha$, the last inequality holds since $1-\alpha(1-\beta^D) - \beta^D(2-\alpha) = (1-2\beta^D)(1-\alpha) \geqslant 0$. Thus, $\frac{h(z,\beta^J)}{h(z,\beta^D)} > 1$.

$$
\begin{aligned}
\frac{l(z,\beta^D)}{l(z,\beta^J)} &= \frac{\alpha(1-\beta^D)(1-z)R(z,\beta^D)/w}{\alpha(1-\beta^J)(1-z)R(z,\beta^J)/w} = \frac{(1-\beta^D)R(z,\beta^D)}{(1-\beta^J)R(z,\beta^J)} \\
&= \frac{(1-\beta^D)[(\beta^D)^z(1-\beta^D)^{(1-z)}]^{\alpha/(1-\alpha)}}{(1-\beta^J)[(\beta^J)^z(1-\beta^J)^{(1-z)}]^{\alpha/(1-\alpha)}} = \frac{(1-\beta^D)[(\beta^D)^z(1-\beta^D)^{(1-z)}]^{\alpha/(1-\alpha)}}{(1/2)^{\alpha/(1-\alpha)}}
\end{aligned}
$$

Define $g(z,\beta) = \ln(1-\beta) + \alpha/(1-\alpha)[z\ln\beta + (1-z)\ln(1-\beta)] - \alpha/(1-\alpha)\ln(1/2)$, then $g'_\beta(z,\beta) = -\frac{1}{1-\beta} + \frac{\alpha}{1-\alpha}\frac{z-\beta}{\beta(1-\beta)} = \frac{\alpha z-\beta}{\beta(1-\beta)(1-\alpha)}$. Thus if $\alpha \leqslant \beta^D/z$, then $g'_\beta(z,\beta) \leqslant 0$. Since $\beta^D < 1/2$, then $g(z,\beta^D) > g(z,1/2) =$

0,which implies $l(z,\beta^D) > l(z,\beta^J)$. Notice $z \in \Omega_{J,F}$, so $z < z^*$, thus $\alpha \leqslant \beta^D/z^*$ is a sufficient but not necessary condition for $l(z,\beta^D) > l(z,\beta^J)$. Similarly, to show $D_2 < D_3$, we only need to show the following term is positive.

$$
\begin{aligned}
&\left[\int_{\Omega_D} l(z,\beta^D)dz \left(\int_{\Omega_F} h(z,\beta^F) - h(z,\beta^J)dz\right) - \int_{\Omega_D} h(z,\beta^D)dz \left(\int_{\Omega_F} l(z,\beta^F) - l(z,\beta^J)dz\right)\right] \\
&+ \left[\int_{\Omega_J} l(z,\beta^J)dz \left(\int_{\Omega_F} h(z,\beta^F) - h(z,\beta^J)dz\right) - \int_{\Omega_J} h(z,\beta^J)dz \left(\int_{\Omega_F} l(z,\beta^F) - l(z,\beta^J)dz\right)\right] \\
&+ \left[\int_{\Omega_F} l(z,\beta^J)dz \int_{\Omega_F} h(z,\beta^F)dz - \int_{\Omega_F} h(z,\beta^J)dz \int_{\Omega_F} l(z,\beta^F)dz\right]
\end{aligned}
$$

The first term

$$
\begin{aligned}
&\int_{\Omega_D} l(y,\beta^D)dy \left(\int_{\Omega_F} h(z,\beta^F) - h(z,\beta^J)dz\right) - \int_{\Omega_D} h(y,\beta^D)dy \left(\int_{\Omega_F} l(z,\beta^F) - l(z,\beta^J)dz\right) \\
&= \int_{y\in\Omega_D}\int_{z\in\Omega_F} l(y,\beta^D)\left(h(z,\beta^F) - h(z,\beta^J)\right) - h(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) dzdy \\
&= \int_{y\in\Omega_D}\int_{z\in\Omega_F} h(z,\beta^J)l(y,\beta^D)\left(h(z,\beta^F)/h(z,\beta^J) - 1\right) - h(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) dzdy \\
&> \int_{y\in\Omega_D}\int_{z\in\Omega_F} h(z,\beta^J)l(y,\beta^D)\left(l(z,\beta^F)/l(z,\beta^J) - 1\right) - h(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) dzdy \\
&= \int_{y\in\Omega_D}\int_{z\in\Omega_F} \frac{h(z,\beta^J)}{l(z,\beta^J)} l(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) - h(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) dzdy \\
&\geqslant \int_{y\in\Omega_D}\int_{z\in\Omega_F} \frac{h(y,\beta^D)}{l(y,\beta^D)} l(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) - h(y,\beta^D)\left(l(z,\beta^F) - l(z,\beta^J)\right) dzdy \\
&= 0
\end{aligned}
$$

The first inequality is due to $h(z,\beta^F)/l(z,\beta^F) > h(z,\beta^J)/l(z,\beta^J)$, and the second is due to $h(z,\beta^J)/l(z,\beta^J) > h(z,\beta^D)/l(z,\beta^D) \geqslant h(y,\beta^D)/l(y,\beta^D)$ for $z \geqslant y$. The second term is positive since

$$
\begin{aligned}
&\int_{\Omega_J} l(y,\beta^J)dy \left(\int_{\Omega_F} h(z,\beta^F) - h(z,\beta^J)dz\right) - \int_{\Omega_J} h(y,\beta^J)dy \left(\int_{\Omega_F} l(z,\beta^F) - l(z,\beta^J)dz\right) \\
&= \int_{y\in\Omega_J}\int_{z\in\Omega_F} l(y,\beta^J)(h(z,\beta^F) - h(z,\beta^J)) - h(y,\beta^J)(l(z,\beta^F) - l(z,\beta^J))dzdy \\
&= \int_{y\in\Omega_J}\int_{z\in\Omega_F} h(z,\beta^J)l(y,\beta^J)(h(z,\beta^F)/h(z,\beta^J) - 1) - h(y,\beta^J)(l(z,\beta^F) - l(z,\beta^J))dzdy \\
&> \int_{y\in\Omega_J}\int_{z\in\Omega_F} \frac{h(z,\beta^J)}{l(z,\beta^J)} l(y,\beta^J)(l(z,\beta^F) - l(z,\beta^J)) - h(y,\beta^J)(l(z,\beta^F) - l(z,\beta^J))dzdy \\
&\geqslant \int_{y\in\Omega_J}\int_{z\in\Omega_F} \frac{h(y,\beta^J)}{l(y,\beta^J)} l(y,\beta^J)(l(z,\beta^F) - l(z,\beta^J)) - h(y,\beta^J)(l(z,\beta^F) - l(z,\beta^J))dzdy \\
&= 0
\end{aligned}
$$

The first inequality is due to $h(z,\beta^F)/l(z,\beta^F) > h(z,\beta^J)/l(z,\beta^J)$, and the second is due to $h(z,\beta^J)/l(z,\beta^J) \geqslant h(y,\beta^J)/l(y,\beta^J)$ for $z \geqslant y$. To show the third term, it is equivalent to show that

$$\frac{\int_{\Omega_F} h(z,\beta^F)dz}{\int_{\Omega_F} l(z,\beta^F)dz} \geqslant \frac{\int_{\Omega_F} h(z,\beta^J)dz}{\int_{\Omega_F} l(z,\beta^J)dz} \tag{E.2}$$

Next we show $h(z,\beta^F) \geqslant h(z,\beta^J)$, and $l(z,\beta^J) \geqslant l(z,\beta^F)$ for $z \in \Omega_F$.This is sufficient for the inequality (E.2).

$$\begin{aligned}\frac{h(z,\beta^F)}{h(z,\beta^J)} &= \frac{\alpha\beta^F zR(z,\beta^F)/q}{\alpha\beta^J zR(z,\beta^J)/q} = \frac{\beta^F\pi(z,\beta^F)/[1-\alpha\beta^F z-\alpha(1-\beta^F)(1-z)]}{\beta^J\pi(z,\beta^J)/[1-\alpha\beta^J z-\alpha(1-\beta^J)(1-z)]}\\ &\geqslant \frac{[2-\alpha]}{[1-\alpha\beta^F z-\alpha(1-\beta^F)(1-z)]/\beta^F}\end{aligned}$$

The inequality is due to $\pi(z,\beta^F) \geqslant \pi(z,\beta^J)$ for $z \in \Omega_F$, and $\beta^J = 1/2$. Let $f(\beta^F,z) = [1-\alpha\beta^F z-\alpha(1-\beta^F)(1-z)]/\beta^F$, and it is easy to show that $f'_z(\beta^F,z) = \alpha(1-2\beta^F)/\beta^F < 0$ since $\beta^F > 1/2$. Thus $f(\beta^F,z) \leqslant f(\beta^F,z_{JF}) < f(\beta^F,1/2) = (1-\alpha/2)/\beta^F < [2-\alpha]$, so we have $h(z,\beta^F) \geqslant h(z,\beta^J)$ for $z \in \Omega_F$.

$$\begin{aligned}\frac{l(z,\beta^F)}{l(z,\beta^J)} &= \frac{\alpha(1-\beta^F)(1-z)R(z,\beta^F)/w}{\alpha(1-\beta^J)(1-z)R(z,\beta^J)/w} = \frac{(1-\beta^F)R(z,\beta^F)}{(1-\beta^J)R(z,\beta^J)}\\ &= \frac{(1-\beta^F)[(\beta^F)^z(1-\beta^F)^{(1-z)}]^{\alpha/(1-\alpha)}}{(1-\beta^J)[(\beta^J)^z(1-\beta^J)^{(1-z)}]^{\alpha/(1-\alpha)}} = \frac{(1-\beta^F)[(\beta^F)^z(1-\beta^F)^{(1-z)}]^{\alpha/(1-\alpha)}}{(1/2)^{\alpha/(1-\alpha)}}\end{aligned}$$

Define $g(z,\beta) = \ln(1-\beta)+\alpha/(1-\alpha)[z\ln\beta+(1-z)\ln(1-\beta)]-\alpha/(1-\alpha)\ln(1/2)$, then $g'_\beta(z,\beta) = -\frac{1}{1-\beta} + \frac{\alpha}{1-\alpha}\frac{z-\beta}{\beta(1-\beta)} = \frac{\alpha z-\beta}{\beta(1-\beta)(1-\alpha)}$. Thus if $\beta \geqslant \alpha z$, $g'_\beta(z,\beta) \leqslant 0$. Since $\beta^F > 1/2$, then $g(z,\beta^F) \leqslant g(z,1/2) = 0$,which implies $l(z,\beta^F) \leqslant l(z,\beta^J)$. Notice $z \in \Omega_F$, so $z < z^*$, and $\alpha \leqslant \beta^F/z^*$ is a sufficient but not necessary condition for $l(z,\beta^F) \leqslant l(z,\beta^J)$. Compare with the case of $l(z,\beta^D)$ and $l(z,\beta^J)$, this condition is relatively weaker.

F Concordance and Variable Definitions

F.1 Concordance

The Chinese National Industry Census 1995 (CNIC1995) is based on Chinese Standard Industrial Classification 1994 (CSIC1994 at 3 digits level), which has similar structure as ISIC REV.3. So we do the industry concordance for manufacturing as follows. First, the National Bureau of Statistics provides the concordance between CSIC1994 and CSIC2002 at 4 digits, and also the concordance between CSIC2002 and ISIC REV.3 at 4 digits level. Thus, we first get the concordance between CSIC1994 (172 groups at 3 digits level) and ISIC REV.3 (125 groups at 4 digits level) through CSIC2002. The concordance between CSIC1994 and ISIC REV.3 requires reclassification and some many-to-many matches occur. For these industries in ISIC REV.3 have multiple matches in CSIC1994, we compute the weighted skill intensity, with the employment share as the weights. Secondly, World Integrated Trade Solution (WITS) provides a concordance between ISIC REV.3 (4 digits) and Harmonized system (6 digits for various versions). Since the China trade data record at least at HS 6 digits level, then we can convert HS 6 digits to ISIC REV.3 (4 digits) as well. Consequently we can match CNIC1995 and trade data based on ISIC REV.3. Once we restrain ourselves to manufacturing, we cover 113 out of 127 groups of ISIC REV.3.

F.2 Provincial variables

lnH/L=the log ratio of the population of college and above relative to non-colleges above age 5, from Annual Population Survey, reported in China Population Statistics Yearbook, 1993-2009. We use the Population Census in 1990 to proxy this measure in 1991.

R&D ratio=R&D expenditure/nominal GDP. Source: China Statistical Yearbook on Science and Technology, 1993-2009. K/Y=capital stock/real GDP, both are in 1978 price. Capital stock is provided by Qian et al. (2007). Real GDP is computed from China Compendium of Statistics 1949-2008, published by China Statistical Bureau, 2009.

Import share of equipment=the imported equipment/domestic equipment output. Following Burstein et al. (2011), we also choose ISIC 29-33 sectors as equipment, including manufacture of machinery and equipment n.e.c., manufacture of office, accounting and computing machinery, manufacture of electrical machinery and apparatus n.e.c., Manufacture of radio, television and communication equipment and apparatus, and manufacture of medical, precision and optical instruments, watches and clocks. We excluded processing import because they are imported for processing. Output data are from Chinese annual industrial survey, CSIC(2002) 35, 36, 39, 40, and 41 sectors. This data source is China industry economy statistical yearbook, available on the website of China data online for years 1999-2008, and China cnki for years 1992-1997. The output data was missing in 1995, 1996 and 1998, we extrapolate the values for these years.

FDI ratio=FDI annual inflow/fixed investment, and the FDI data is from China data online, and fixed investment is from China Compendium of Statistics 1949-2008.

Infrastructure=Log(the total mileage of highways and railways in province j up to year t)-Log(the minimum distance to the two major ports: Hong Kong and Shanghai). The mileage of highways and railways are from China Compendium of Statistics 1949-2008. The distance is computed by using Haversine formula, based on the latitude and longitude of each provincial capital, Hong Kong and Shanghai.

The cumulative number of national policy zones: The data source is China Development Zone Review Announcement Catalogue, provided by NDRC, 2007.

Table 1: The Kolmogorov-Smirnov Test for Stochastic Dominance

	$G^F(z)$ and $G^J(z)$		$G^J(z)$ and $G^D(z)$	
	Two-sided test (1)	One-sided test (2)	Two-sided test (3)	One-sided test (4)
1992	0	0	0	0
1993	0	0	0	0
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	1	0
1998	1	0	1	0
1999	1	0	1	0
2000	1	0	1	0
2001	1	0	1	0
2002	1	0	1	0
2003	1	0	1	0
2004	1	0	1	0
2005	1	0	1	0
2006	1	0	1	0
2007	1	0	1	0
2008	1	0	1	0

Note: 1=reject, 0= fail to reject, at 10% significant level.

Table 2: The Kolmogorov-Smirnov Test for Skill Upgrading

		$G_{t+5}(z)$ and $G_t(z)$	
		Two-sided test	One-sided test
Chinese-owned firms	1992-1997	1	0
	1997-2002	1	0
	2002-2007	1	0
Joint ventures	1992-1997	1	0
	1997-2002	1	0
	2002-2007	1	0
foreign-owned firms	1992-1997	1	0
	1997-2002	1	0
	2002-2007	1	0

Note: 1=reject, 0= fail to reject, at 10% significant level.

Table 3: Determinants of Processing Exports to the Rest of World

Independent variables	OLS (1)	OLS (2)	IV (3)	IV-After 2001 (4)
Domestic firm × encouragement policy	0.057	0.096	0.087	0.308***
	(0.068)	(0.071)	(0.071)	(0.112)
Joint venture × encouragement policy	0.197***	0.189***	0.185***	0.414***
	(0.066)	(0.068)	(0.068)	(0.111)
Foreign firm × encouragement policy	0.478***	0.473***	0.440***	0.507***
	(0.069)	(0.072)	(0.071)	(0.100)
Domestic firm × restriction policy	-0.007	0.016	0.046	0.023
	(0.056)	(0.058)	(0.058)	(0.104)
Joint venture × restriction policy	-0.162***	-0.135**	-0.134**	-0.156
	(0.061)	(0.061)	(0.061)	(0.114)
Foreign firm × restriction policy	-0.496***	-0.463***	-0.458***	-0.259**
	(0.061)	(0.061)	(0.060)	(0.106)
Joint venture × court efficiency	2.006***	2.192***	3.121***	4.068***
	(0.475)	(0.498)	(0.804)	(0.784)
Foreign firm × court efficiency	2.049***	2.275***	3.928***	5.998***
	(0.767)	(0.792)	(1.236)	(1.097)
Domestic firm × trade cost	0.004	0.013	0.007	0.017**
	(0.011)	(0.012)	(0.012)	(0.009)
Joint venture × trade cost	0.036***	0.033***	0.025**	0.020***
	(0.011)	(0.011)	(0.011)	(0.007)
Foreign firm × trade cost	0.119***	0.118***	0.112***	0.087***
	(0.011)	(0.012)	(0.013)	(0.008)
Skill intensity × college share		0.006***	0.005***	0.004***
		(0.001)	(0.001)	(0.001)
Capital intensity × capital-to-output ratio		0.037**	0.032**	0.114***
		(0.015)	(0.014)	(0.022)
Constant	11.822***	12.661***	12.664***	10.651***
	(0.204)	(0.380)	(0.391)	(0.489)
First stage F-stat			> 52.44	> 28.54
Dummies for ownership, industry, province and year	yes	yes	yes	yes
N	55,989	52,080	52,080	24,336
R^2	0.463	0.462	0.460	0.434

Note: dependent variable: log(processing exports value). The panel covers 29 provinces and 112 industries in 1992-2007. Regression (3) and (4) are estimated by GMM, with instruments for court efficiency and its interactions. Cluster robust standard errors are in parentheses. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

Table 4: Determinants of Processing Exports to High-income Countries

Independent variables	OLS (1)	OLS (2)	IV (3)	IV-After 2001 (4)
Domestic firm × encouragement policy	0.004	0.035	0.011	0.191*
	(0.069)	(0.071)	(0.071)	(0.112)
Joint venture × encouragement policy	0.194***	0.182***	0.166**	0.325***
	(0.067)	(0.069)	(0.069)	(0.111)
Foreign firm × encouragement policy	0.504***	0.497***	0.462***	0.501***
	(0.072)	(0.075)	(0.074)	(0.109)
Domestic firm × restriction policy	-0.062	-0.027	0.011	0.002
	(0.060)	(0.063)	(0.062)	(0.107)
Joint venture × restriction policy	-0.198***	-0.165**	-0.168**	-0.170
	(0.064)	(0.065)	(0.066)	(0.119)
Foreign firm × restriction policy	-0.550***	-0.513***	-0.519***	-0.307***
	(0.064)	(0.064)	(0.063)	(0.114)
Joint venture × court efficiency	1.978***	2.146***	3.061***	4.219***
	(0.462)	(0.480)	(0.801)	(0.814)
Foreign firm × court efficiency	1.686**	1.925**	4.258***	6.229***
	(0.756)	(0.775)	(1.154)	(0.944)
Domestic firm × trade cost	0.007	0.018	0.014	0.019**
	(0.011)	(0.012)	(0.012)	(0.009)
Joint venture × trade cost	0.033***	0.033***	0.027**	0.020***
	(0.011)	(0.011)	(0.011)	(0.007)
Foreign firm × trade cost	0.117***	0.117***	0.110***	0.085***
	(0.011)	(0.012)	(0.013)	(0.008)
Skill intensity × college share		0.006***	0.005***	0.004***
		(0.001)	(0.001)	(0.001)
Capital intensity × capital-to-output ratio		0.026*	0.018	0.110***
		(0.015)	(0.015)	(0.023)
Constant	11.784***	12.646***	12.688***	10.646***
	(0.199)	(0.389)	(0.397)	(0.521)
First stage F-stat			> 51.05	> 27.57
Dummies for ownership, industry, province and year	yes	yes	yes	yes
N	52,959	49,260	49,260	23,033
R^2	0.465	0.465	0.463	0.442

Note: The sample covers China's processing exports to high-income countries. The panel covers 29 provinces and 112 industries in 1992-2007. The dependent variable is log(processing exports value). Regression (3) and(4) are estimated by GMM, with instruments for court efficiency and its interactions. Cluster robust standard errors are in parentheses. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

Table 5: Determinants of College Premium: Processing Exports to the Rest of World

	OLS			IV[a]	
Independent variables	(1)	(2)	(3)	(4)	(5)
College indicator	0.350***	0.281***	0.248***	0.404***	0.370***
	(0.009)	(0.018)	(0.036)	(0.031)	(0.060)
College indicator interaction terms					
College $\times$ processing exports ratio		0.531***	0.773***	0.643***	0.709***
		(0.115)	(0.106)	(0.140)	(0.109)
College $\times$ Share of foreign owned		0.236***	0.238***	0.112*	0.075
		(0.044)	(0.043)	(0.059)	(0.059)
College $\times$ Share of joint venture		-0.092**	0.019	-0.438***	-0.273**
		(0.044)	(0.043)	(0.098)	(0.118)
College $\times$ R&D ratio			-0.708		0.194
			(0.667)		(0.982)
College $\times$ Import share of equipment			0.003		-0.073*
			(0.033)		(0.039)
College $\times$ FDI ratio			-0.786***		-0.549***
			(0.116)		(0.129)
College $\times K/Y$			0.027		0.007
			(0.020)		(0.027)
College $\times$ Ordinary export ratio			0.312**		0.530***
			(0.134)		(0.179)
Individual characteristics					
Experience	0.048***	0.048***	0.048***	0.047***	0.047***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Experience square	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sex	-0.202***	-0.202***	-0.202***	-0.208***	-0.208***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Stated owned sector	0.195***	0.197***	0.197***	0.193***	0.193***
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)
Constant	8.198***	8.207***	8.214***	-	-
	(0.021)	(0.021)	(0.023)		
First stage F-stat				> 48.48	> 22.96
Province-year pair dummy	yes	yes	yes	yes	yes
N	156,658	156,658	155,905	143,599	143,599
R^2	0.366	0.369	0.370	0.118	0.119

Note: the dependent variable is log annual wage income. Our key variables are based on the sample of China's all trade partners. Province-year cluster robust standard errors in parentheses. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

[a] Regressions (4) and (5) are estimated by GMM, where we use the constructed variables of processing exports ratio, processing exports shares of foreign-owned firms and joint ventures as instruments, based on the sample of high-income countries. The regressions partial out the constant and province-year fixed effect by using a two-stage procedure, in the sense of the Frisch-Waugh-Lovell (FWL) theorem. Thus, the coefficient of constant is not reported, and the R^2 is the residual R-square without including the contribution of the constant and the province-year fixed effect.

Table 6: Determinants of College Premium: Processing Exports to High-income Countries

	OLS			IV[a]	
Independent variables	(1)	(2)	(3)	(4)	(5)
College indicator	0.350***	0.279***	0.236***	0.402***	0.381***
	(0.009)	(0.019)	(0.039)	(0.032)	(0.064)
College indicator interaction terms					
College × processing exports ratio		0.566***	0.819***	0.598***	0.696***
		(0.131)	(0.125)	(0.140)	(0.107)
College × Share of foreign owned		0.237***	0.240***	0.150***	0.119**
		(0.044)	(0.044)	(0.053)	(0.057)
College × Share of joint venture		-0.068	0.043	-0.403***	-0.265**
		(0.045)	(0.045)	(0.093)	(0.111)
College × R&D ratio			-0.504		0.356
			(0.718)		(0.967)
College × Import share of equipment			-0.008		-0.055
			(0.033)		(0.042)
College × FDI ratio			-0.783***		-0.548***
			(0.120)		(0.128)
College $\times K/Y$			0.031		-0.002
			(0.021)		(0.029)
College × Ordinary export ratio			0.364***		0.490**
			(0.140)		(0.193)
First stage F-stat				> 52.69	> 28.79
Individual characteristics and the constant	yes	yes	yes	yes	yes
Province-year pair dummy	yes	yes	yes	yes	yes
N	156,658	156,658	155,905	143,599	143,599
R^2	0.366	0.369	0.370	0.118	0.119

Note: the dependent variable is log annual wage income. Our key variables are based on the sample of China's high-income trade partners. For brevity, we do not report the coefficients of individual characteristics and the constant. Province-year cluster robust standard errors in parentheses. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

[a] See the note in Table 5.

Table 7: Determinants of Return to Education: Processing Exports

	The Rest of World		High-income Countries	
	OLS	IV[a]	OLS	IV [a]
Independent variables	(1)	(2)	(3)	(4)
Edu	0.039***	0.060***	0.034***	0.059***
	(0.006)	(0.009)	(0.007)	(0.010)
Edu interaction terms				
Edu × processing exports ratio	0.111***	0.122***	0.113***	0.119***
	(0.020)	(0.018)	(0.023)	(0.018)
Edu × Share of foreign owned	0.066***	0.035***	0.066***	0.043***
	(0.007)	(0.009)	(0.007)	(0.009)
Edu × Share of joint venture	0.032***	-0.019	0.037***	-0.016
	(0.007)	(0.018)	(0.008)	(0.018)
Edu × R&D ratio	0.038	0.282	0.090	0.338*
	(0.162)	(0.174)	(0.176)	(0.178)
Edu × Import share of equipment	-0.002	-0.021***	-0.006	-0.020***
	(0.007)	(0.007)	(0.007)	(0.007)
Edu × FDI ratio	-0.172***	-0.155***	-0.170***	-0.154***
	(0.016)	(0.017)	(0.017)	(0.017)
Edu $\times K/Y$	0.005	0.003	0.007*	0.003
	(0.003)	(0.004)	(0.004)	(0.004)
Edu × Ordinary export ratio	0.023	0.053*	0.039	0.051
	(0.030)	(0.032)	(0.030)	(0.035)
First stage F-stat		> 26.13		> 28.79
Individual characteristics and constant	yes	yes	yes	yes
Province-year pair dummy	yes	yes	yes	yes
N	155,905	143,599	155,905	143,599
R^2	0.378	0.131	0.378	0.131

Note: the dependent variable is log annual wage income. For brevity, we do not report the coefficients of individual characteristics and the constant. Province-year cluster robust standard errors in parentheses. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

[a] See the note in Table 5.

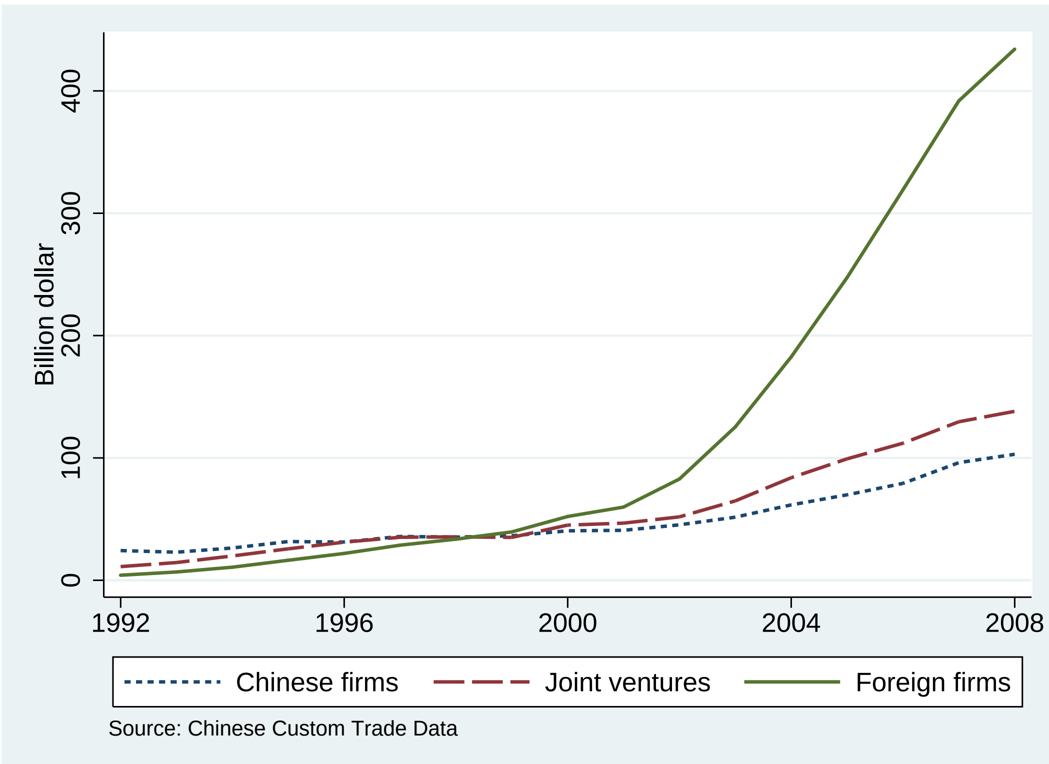

Figure 1: Processing Exports by Firm Ownership Types: 1992-2008

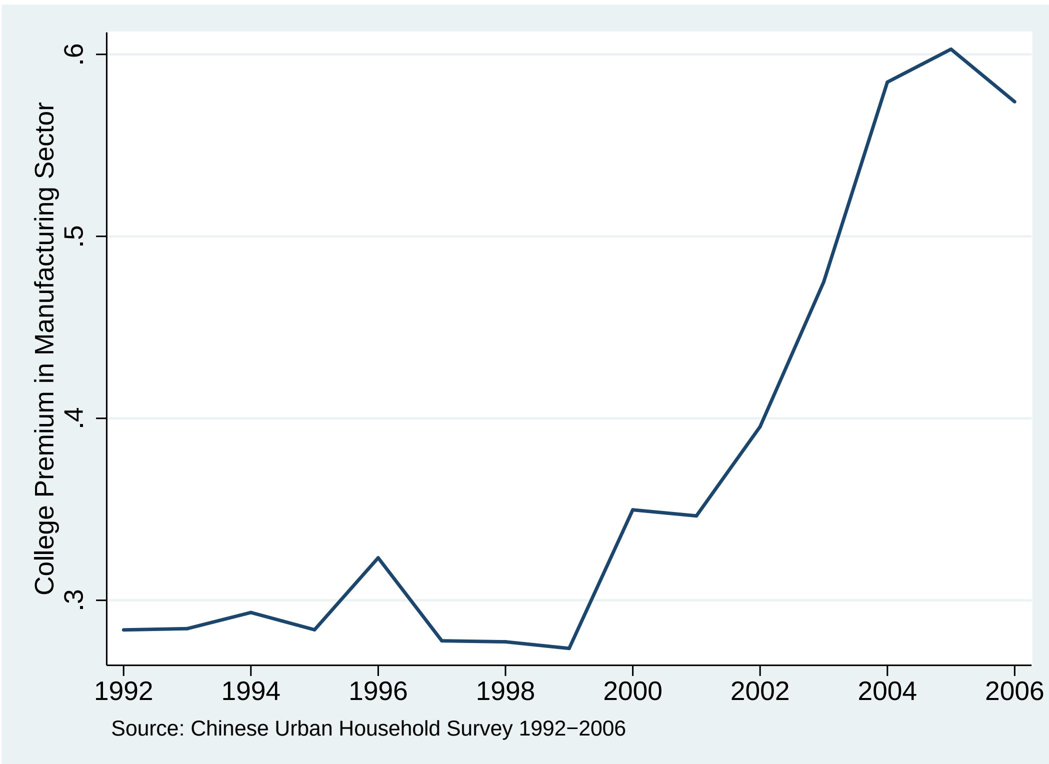

Figure 2: College Premium in Manufacturing Sector: 1992-2006

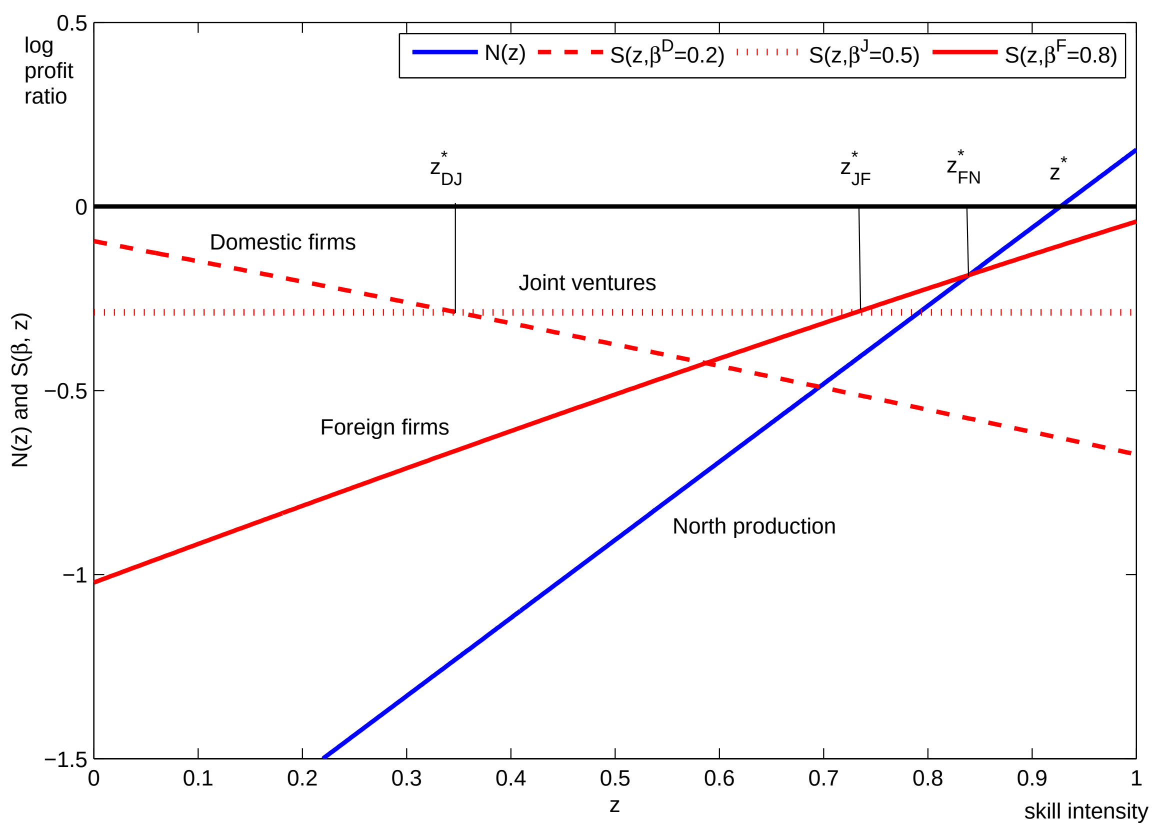

Figure 3: Offshoring, Optimal Ownership and Skill Intensity of Intermediate Goods

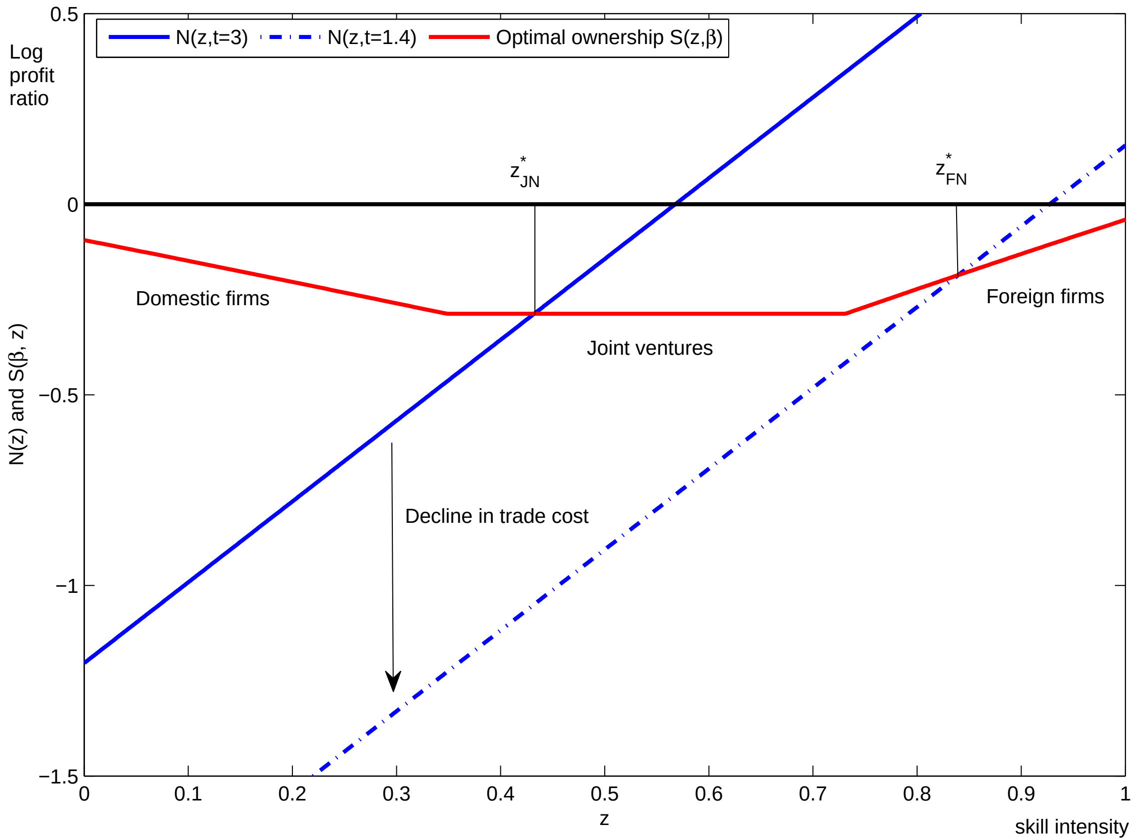

Figure 4: Trade liberalization, Offshoring and Skill Intensity of Intermediate Goods

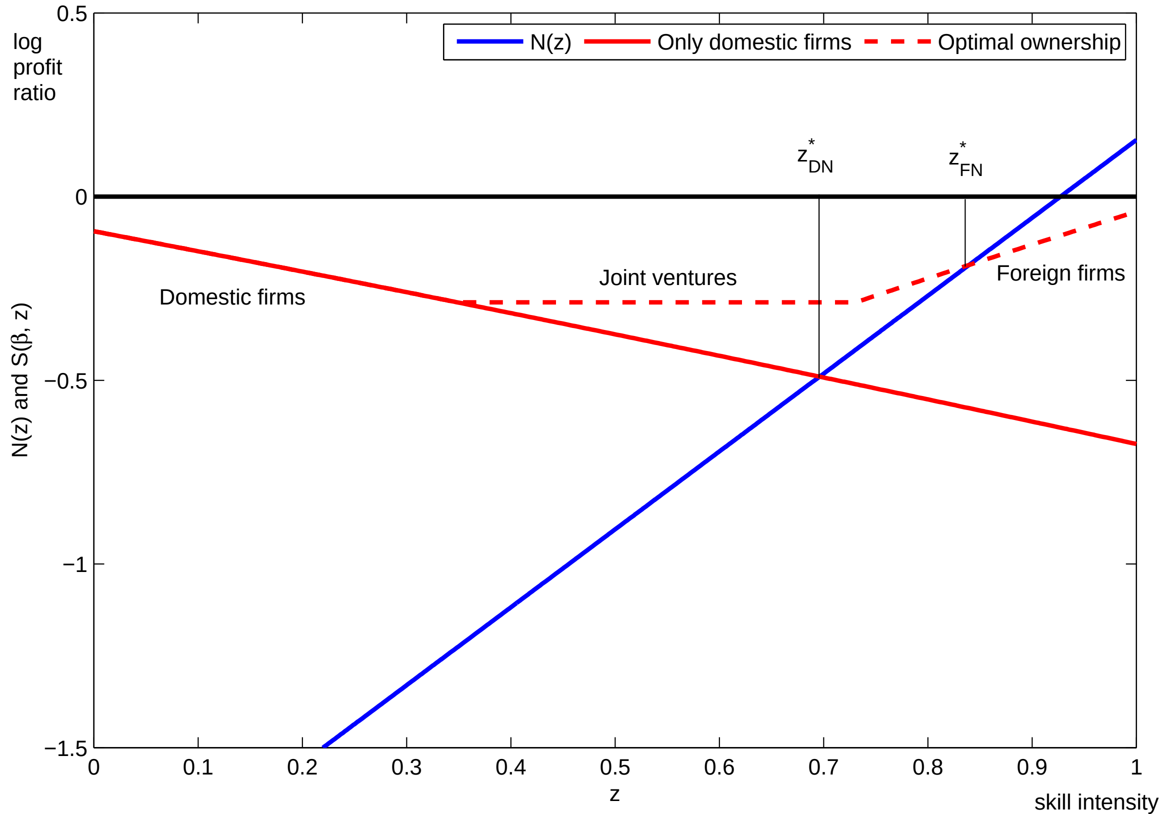

Figure 5: Ownership liberalization, Offshoring and Skill Intensity of Intermediate Goods

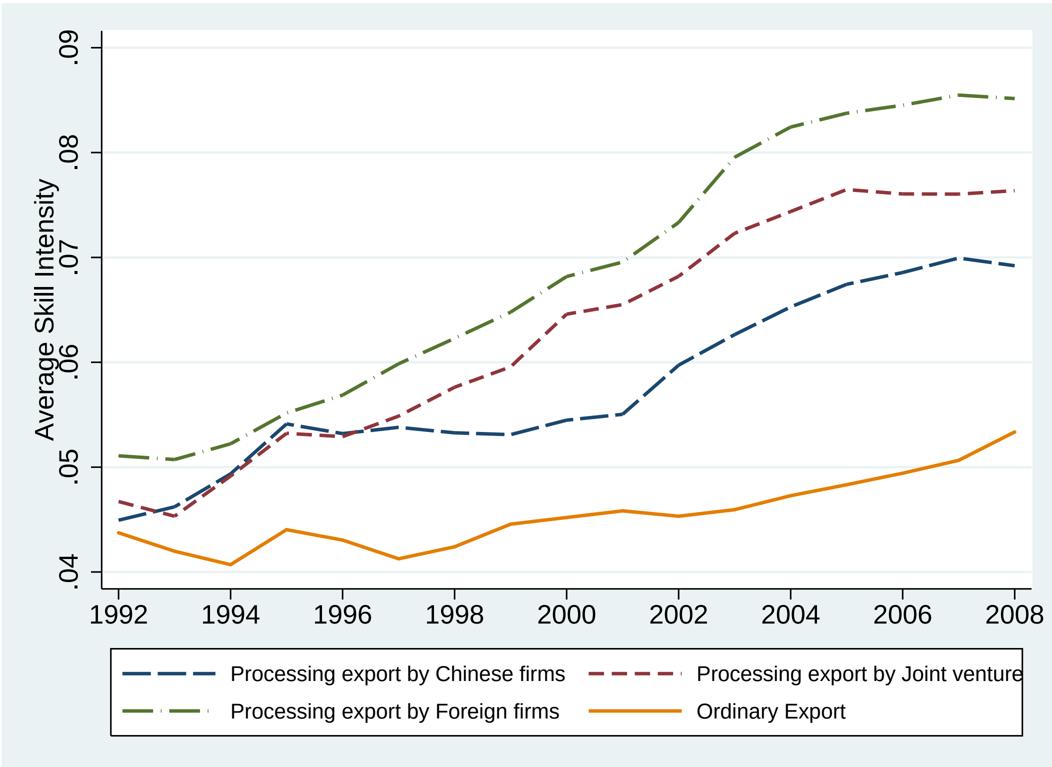

Figure 6: Average Skill Intensity of Processing and Ordinary Export: 1992-2008.

The average skill intensity is measured as the weighted average of industrial skill intensity, with industrial export shares as the weights, where the skill intensity is measured by the share of college workers within each industry using the 1995 Chinese National Industry Census. Thus the rising average skill intensity reflects sectoral shifts toward more skill-intensive industries in exports. See more discussion in Section 4.1.

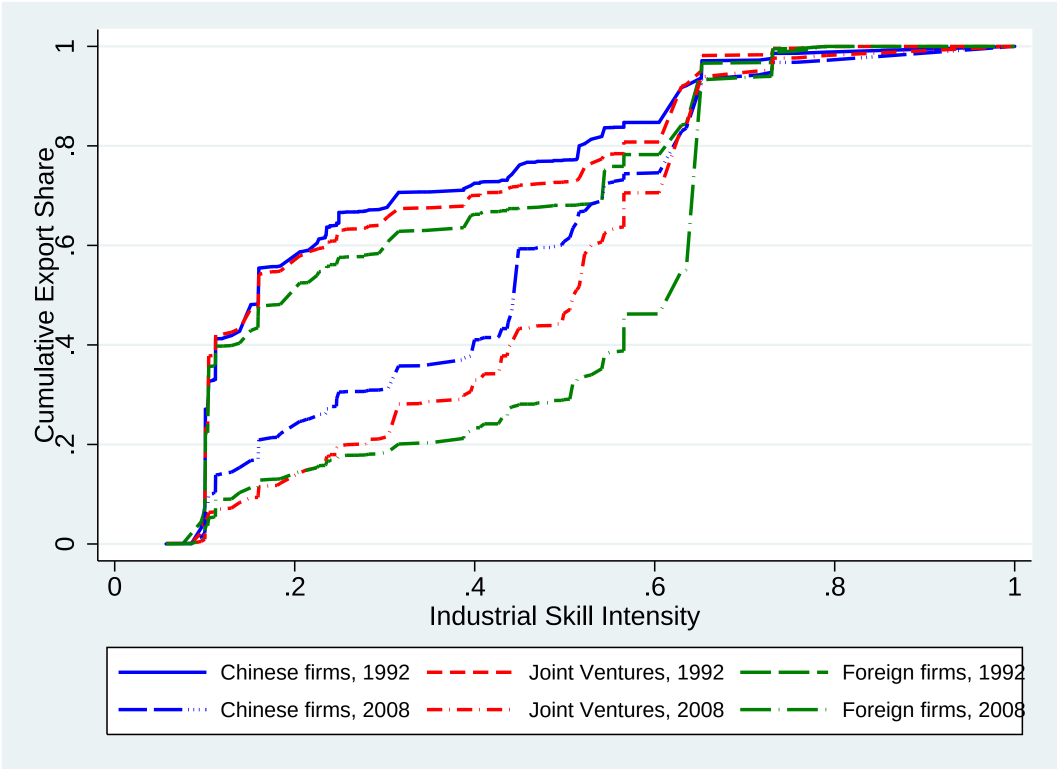

Figure 7: The Cumulative Distribution of Processing Exports by Firm Ownership Types: 1992 and 2008

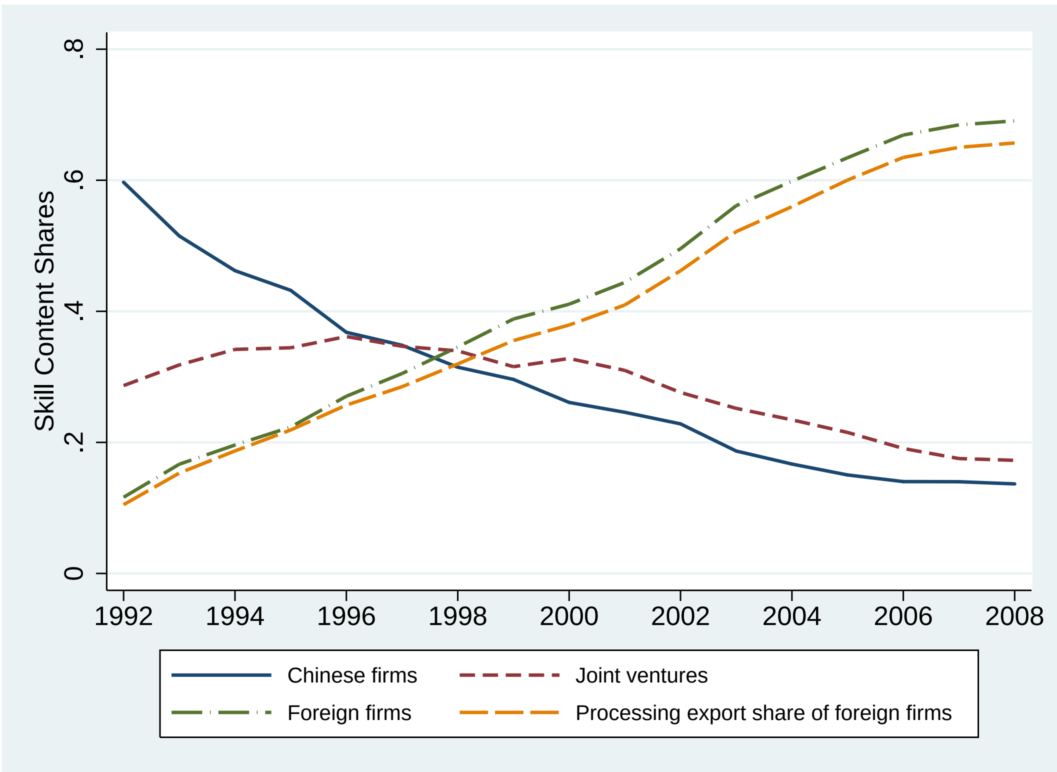

Figure 8: The Skill Content Share of Processing Exports by Firm Ownership Types:1992-2008