Offshoring and Wage Inequality: Theory and Evidence from China[†]

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Abstract

We develop a global production sharing model that integrates the frameworks of ownership structure of offshoring and the determination of relative wages in developing countries. The model shows that FDI offshoring contributes more prominently than arm's length outsourcing to the demand for skill in the South, which raises the returns to education. By incorporating these theoretical results into an augmented Mincer earnings function, we test the model using a natural experiment in which China lifted its restrictions on foreign ownership of FDI upon its accession to the WTO. Empirical findings based on detailed Urban Household Surveys and trade data from Chinese customs provide support to the proposed theory, thus shedding light on the changes in firm ownership structure, the skill content of exports, and the evolution of wage inequality for the period of 1992-2008 in China.

Key words: offshoring, ownership structure, processing trade, wage inequality, China

JEL classification: F16, J31, D23

1 Introduction

Globalization has changed the nature of international trade. For centuries, conventional trade primarily involved the exchange of final goods across countries. Over the last several decades, trade in intermediate inputs - offshoring through both foreign direct investment (FDI) and arm's length outsourcing – have gained prominence in the global economy. Now roughly two-thirds of world trade is trade in intermediate inputs, and approximately half of that is within the boundaries of multinational companies.[1] The rise in offshoring and corresponding changes in organizational structures raise important questions on the distributional effects on factor prices. How does offshoring influence wage inequality? Do FDI offshoring and arm's length outsourcing from the North affect skill demand differently in developing countries?

Extensive studies have investigated the effect of globalization on wage inequality over the last two decades.[2] The seminal paper by Feenstra and Hanson (1996a) shows that offshoring from the North to the South can increase skill premium in both economies,[3] but recent studies suggest that the effect of offshoring on wage inequality depends on the skill contents of the offshored tasks (Grossman and Rossi-Hansberg, 2008; Acemoglu and Autor, 2011; Hummels et al., 2014a). Thus far, the literature has mainly focused on the effect of aggregate offshoring size on wage inequality without distinguishing FDI and arm's length offshoring, and hence neglected the extensive evidence that the offshored tasks vary across organizational forms (Antràs, 2003; Costinot et al., 2011). Meanwhile, another booming strand of the literature of offshoring focuses on firm's choice of organizational form. These studies have successfully demonstrated various determinants for organization forms, however, no research has yet linked organization form of offshoring to wage inequality.[4] To bridge the gap, this paper develops an integrated framework to analyze the orga-

[1] See Johnson and Noguera (2011). According to UNCTAD (1999, p.232), approximately one-third of world trade was intermediate inputs traded within firm boundaries in 1996. Thus, FDI offshoring contributes approximately half of total offshoring.

[2] A recent literature review by Goldberg and Pavcnik (2007) finds that the classical Heckscher-Ohlin model fails to explain the empirical findings of the worldwide rising wage inequality along with globalization.

[3] Subsequent studies including Feenstra and Hanson (1996b, 1997, 1999) and Hsieh and Woo (2005) find that offshoring contributes modestly to the rising wage inequality in U.S., Mexico, and Hong Kong in 1980s and 1990s. For a recent literature review see Hummels et al. (2014b).

[4] See, for example, Grossman and Helpman (2002, 2005), Antràs (2003, 2005), Antràs and Helpman (2004),

nization form of offshoring in shaping skill demand and wage inequality in developing countries, and provides systematic empirical evidence by using recent data from China, a fast-growing large developing economy. Consistent with the model, our empirical analysis shows that the ownership structure of offshoring plays a key role in understanding skill upgrading in Chinese exports and widening wage inequality for the period of 1992-2008 in China.

The main theoretical innovation of this paper is to integrate the analyses of ownership structure of offshoring with the determination of relative wages in developing countries (Feenstra and Hanson, 1996a). More specifically, by introducing two types of labor into the framework of Antràs (2005), we are able to explore the implications of offshoring for skill demand in the South. With incomplete contracts, multinational companies have incentives to choose FDI offshoring for skill-intensive production, but prefer arm's length outsourcing for low-skill activities. The model predicts that ownership liberalization for multinationals and further reduction in offshoring cost in host countries can attract more skill-intensive production and thus raise the skill premium in the South. Given the prevalent ownership restrictions on the operation of multinational companies in many developing countries (Kalinova et al., 2010; UNCTAD, 2006), this paper forges a novel and potentially important linkage between globalization and wage inequality. To test this channel, we link our theoretic predictions on skill premium directly to empirical testing by developing an augmented Mincer wage regression, which provides a useful empirical specification to study the market determinants of skill premium (Heckman et al., 2006). Thus, we can directly test whether FDI offshoring contributes more to the skill premium.

China provides an intriguing natural experiment to test the major implications of our model. The Chinese government has imposed restrictions on (wholly) foreign ownership but rather encouraged joint ventures for foreign direct investment until late 1990s. Upon its accession to the World Trade Organization (WTO) in 2001, China was forced to remove the ownership restrictions, together with other trade liberalization reform in manufacturing sector. Since then China has grown from a negligible player in international market to the world's largest exporter and

Feenstra and Hanson (2005), Nunn and Trefler (2008), and Fernandes and Tang (2012). Please see Helpman (2006) for a comprehensive review of trade, FDI and firm organizations.

the largest recipient of foreign direct investment among developing countries. Moreover, wholly foreign-owned affiliates have increased dramatically and played the dominant role in both foreign direct investment and Chinese processing trade since the middle of 2000s. This ownership liberalization, induced largely by external factors, presents an unique opportunity to investigate the effects of the change in ownership structure of offshoring on skill upgrading in exports and skill premium in China.

Below we presents two striking empirical facts in Figure 1 that are consistent with our model predictions. FDI offshoring, measured as processing exports by wholly foreign-owned enterprises, accelerated to a considerably much steeper trajectory of growth shortly after 2001 as shown in panel (a). By contrast, arm's length offshoring, which are defined as processing exports by joint ventures and Chinese domestic firms, grew far less strikingly.[5] Meanwhile, as illustrated in panel (b), the college wage premium in the Chinese manufacturing sector remained flat before 2001, but increased dramatically thereafter. The average earnings gap between those with and without college education was approximately 30 percent throughout the 1990s, but this skill premium rose to 55 percent by 2006. These two facts are not just an coincidence, instead our model suggests that the ownership liberalization on foreign investment around China's accession to WTO led to the dramatic increase in FDI offshoring, which in turn increased the skill demand and skill premium in China.

To test the causal effects of ownership liberalization of foreign investment on trade pattern and wage inequality, we collect three comprehensive data sources: the ownership liberalization measure at industrial level constructed by ourselves (1995-2007), Chinese customs trade data (1992-2008), and the Chinese Urban Household Surveys (CUHS 1992-2006) to which we have unique access. Based on the official government regulation list of industries that wholly foreign ownership of direct investment is encouraged, restricted (and prohibited), we constructed two policy

[5]We use processing exports as a measure of offshoring because it involves a foreign firm that either works with its own affiliates or contracts with local firms to assemble imported inputs with local factors, and re-exports the products to foreign markets. In other words, processing exports are the offshored production from foreign countries (Feenstra and Hanson, 2005). Processing exports play a major role in China's international trade, accounting for an average of 56 percent of the country's total exports from 1992 to 2008.

indicator variables for "encouragement" and "restriction" at industrial level respectively. The trade data contain detailed information on export value broken down by customs regions, firm ownership, origins of exporters, destinations and products. The CUHS data include individual household characteristics such as residential location, education, gender, earnings, and work experience.

Our identification strategy includes two stages: we test first whether ownership liberalization policy and reduction in offshoring cost increase FDI offshoring more than arm's length offshoring, and second whether FDI offshoring contributes more to the skill premium. The first part of empirical analysis shows that FDI offshoring is more skill intensive than arm's length offshoring, which is the key implication of the model. Moreover, we find that a high degree of ownership liberalization and reduction in offshoring cost increase FDI offshoring more than arm's length offshoring.

For the second stage, we use the augmented Mincer regression to test differential impacts of the two types of offshoring on skill premium. Since both the trade and CUHS data sets cover all Chinese provinces, we can take advantage of the rich spatial variations in trade exposure. The augmented Mincer regression provides a useful specification to estimate the skill premium using individual data but incorporating the demand and supply factors of local labor market. As a result, we find that both the aggregate size of offshoring, measured as the ratio of processing exports to industrial output, and the share of FDI offshoring are important determinants of college wage premium across the Chinese provinces. This results is robust to the inclusion of various control variables and array of sensitivity checks. Quantitatively, the size of processing exports and the share of FDI offshoring can account for 63 percent of the total increase in college wage premium in Chinese manufacturing between 2000 and 2006. FDI offshoring alone can explain approximately 55 percent of the rising college premium during this period.

This paper contributes to the literature on the organizational forms of multinationals in global production. Previous research mainly focuses on the determinants of organizational forms. To the best of our knowledge, this study is the first to examine the differential effects of organization forms on (relative) factor prices, and analyze the effects of ownership liberalization on trade structure and labor market outcomes in a large developing country. Moreover, understanding the linkage between ownership structure in offshoring and wage inequality also has important policy significance because restrictions on foreign ownership are major barriers to multinational production in many developing countries.

This paper also contributes to the literature of globalization and wage inequality. First, most recent studies exploring the contribution of firm heterogeneity to the rising demand for high-skilled labor are based on the sorting mechanism of Melitz (2003)[6], whereas our approach focuses on the heterogeneous organizational forms of offshoring. This approach points to a new mechanism and has strong policy implications for developing countries. Secondly, limited research has been conducted on the effect of globalization on income distribution in China (Goldberg and Pavcnik, 2007), with the exception of Han et al. (2011).[7] Such limitation is a serious void in the literature because of China's emerging role as the "world factory"and the profound changes in income distribution in recent decades. Our empirical findings contribute to the understanding of the effect of recent globalization on income inequality because of China's significance among developing countries.

The reminder of this paper is organized as follows: Section 2 develops the theoretical framework and presents an augmented Mincer earnings equation, as well as the identification strategy. Section 3 briefly describes China's globalization process, the natural experiment of policy changes, and the data used for empirical analysis. Section 4 presents the empirical findings. The final section presents our tentative and incomplete concluding remarks with relevant policy discussions.

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

[7]Han et al. (2011) also find rising wage inequality in China by using a part of CUHS data that covers five Chinese provinces. Their study is empirical and does not provide a theoretical framework to explain the sources of wage inequality.

2 Offshoring, Ownership Structure and Skill Premium

This section develops a model introducing ownership structure into the offshoring framework in a two-country setting, and shows how multinational firms jointly decide on offshoring, ownership structure and skill demand subject to trade and contractual frictions. The model not only presents a theoretical framework to analyze the impact of ownership and trade liberalization on the offshoring structure and aggregate wage inequality in developing countries, but also provides guidance for empirical analysis.

2.1 Setup

The world consists of two countries, the North and the South. There are two types of labor immobile across the border: 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. We assume that the North produces both the final good Y and intermediate goods, while the South only produces intermediate goods.

The final-good producer in the North is assumed to assembly costless over a continuum of differentiated products indexed by $z \in [0, 1]$ with a constant-elasticity-of-substitution form in a given industry. The producer of each differentiated final good z faces the demand function $y(z) = \lambda p(z)^{-1/(1-\alpha)}, 0 < \alpha < 1$, where $y(z)$ and $p(z)$ denote quantity and price, respectively. Moreover, λ measures aggregate demand for the differentiated goods under the assumption that goods are freely shipped without costs, and α determines demand elasticity.

The production of the intermediate good z is given by $y(z) = \xi_z x_h^z x_l^{1-z}$, where $\xi_z = z^{-z}(1 - z)^{-(1-z)}$, and $0 \leq z \leq 1$. x_h is the high-tech input and x_l is the low-tech input. A higher z indicates more intensive use of high tech in production. The model is closely related to Antràs (2005), but it makes two crucial differences. Firstly, there is only one type of labor in Antràs (2005), while this model has two types of labor so that we can explore the impact of offshoring on relative factor prices. For simplicity, we assume that one unit of high-tech (low-tech) input requires one unit of high-skilled labor h (low-skilled l) .[8] Secondly, we 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.[9]

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 supplier also needs to pay her a lump-sum transfer T and this transfer would make the supplier break even. If the Northern innovator sources the low-tech inputs from domestic suppliers, the contract is assumed to be complete. However, if she offshores the inputs then she faces the incomplete contracts as the legal environment in the South is poor. However, the Northern innovators can choose the ownership of their joint production; she can either set up a foreign affiliate ($O = F$), or outsource to the Southern suppliers ($O = D$). Beside the incomplete contract, offshoring requires an additional effort in managing business overseas (Grossman and Rossi-Hansberg, 2008). We assume this offshoring cost is proportional to the output of good z, which means that for one unit of z, the offshoring cost is $t - 1$ units where $t \geq 1$.

Consider a Northern innovator who locates her production in the North. Because the contract is complete in the North, the Northern innovator chooses the low-tech x_l, and high-tech x_h, to maximize $\pi = R(z) - q^N h^N - w^N l^N$, given $R(z) = \lambda^{1-\alpha} y(z)^\alpha$. This yields the profit:

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

If the Northern innovator opts to offshore, the Northern innovator and the Southern supplier will bargain over the surplus from their relation-specific investment after production due to the incomplete contracts. Thus, the supplier sets l^S to maximize $(1-\beta)R(z) - w^S l^S$, and the innovator

[8]This assumption can be relaxed to have different labor productivities in different countries.

[9]We follow the approach of Feenstra and Hanson (1996a, 1997) to model 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 discussion of these two approaches and their implications of offshoring and wage inequality.

sets h^S to maximize $\beta R(z) - q^S h^S$, where $R(z) = \lambda^{1-\alpha} y(z)^\alpha / t^\alpha$ and $\beta \in [0,1]$ denotes the revenue share of the Northern innovator. The Northern innovator finalizes the contract by setting T so as to make the low-tech supplier break even and obtain the *ex ante* profit as follows:

$$\pi^S(z,\beta) = \lambda(\frac{1}{t})^{\alpha/(1-\alpha)}[\alpha(\beta/q^S)^z((1-\beta)/w^S)^{(1-z)}]^{\alpha/(1-\alpha)}[1 - \alpha\beta z - \alpha(1-\beta)(1-z)] \quad (2)$$

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

The Northern innovator's revenue share β is determined by the ownership structure. 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 δ fraction of the output where $0 < \delta < 1$, which in turn generates sale revenue of $\delta^\alpha R$. The quasi-rent of this relationship is $(1-\delta^\alpha)R$. Symmetric Nash Bargaining leaves each party with its outside option plus one-half of the quasi-rent. Thus, the ex post revenue share of the Northern innovator is $\beta^F = \frac{1}{2}(1+\delta^\alpha)$. By contract, if the Southern supplier owns the firm ($O = D$), the innovator's share in revenue is $\beta^D = \frac{1}{2}(1-\delta^\alpha)$. Clearly we have $0 < \beta^D < 1/2 < \beta^F < 1$.[10]

2.2 Location and ownership choice

The Northern innovator's ex ante profit is given by $\pi(z) = \max\{\pi^N(z), \pi^S(z,\beta^F), \pi^S(z,\beta^D)\}$. Comparing to the North, the South has abundant cheap low-skilled labor, but it suffers the iceberg offshoring cost and efficiency loss due to the incomplete contracts. To separate the effect of comparative advantage and offshoring costs from the frictions of incomplete contracts on offshoring, we introduce a hypothetical case where the South also has complete contracts, and obtain easily the profit $\pi^S(z) = (1-\alpha)\lambda[\alpha(1/q^s)^z(1/w^s)^{(1-z)}]^{\alpha/(1-\alpha)}(1/t)^{\alpha/(1-\alpha)}$.

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

[10] We do not include joint venture as the qualitative results still hold without joint ventures. In previous version, we included the joint venture with $\beta = 1/2$, indicating that both parties have the veto power.

production both with complete contracts:

$$N(z) \equiv \frac{1-\alpha}{\alpha}\ln(\pi^N(z)/\pi^S(z)) = z\ln(\omega_l/\omega_h) - \ln\omega_l + \ln t \tag{3}$$

where $\omega_h = q^N/q^S$, and $\omega_l = w^N/w^S$. Because the North has more abundant high-skilled labor, it is reasonable to assume $\omega_h < \omega_l$. To rule out the extreme case that all products are produced in one location, we assume $\omega_h < t < \omega_l$. In this case, $N(z)$ increases in z, and there exists an unique interior solution $z^*(t) \in (0,1)$ such that $N(z^*(t)) = 0$. Thus, more skill-intensive intermediate goods ($z > z^*(t)$) are produced in the North, and less skill-intensive intermediate goods ($z < z^*(t)$) are offshored to the South. In this artificial case, our model is the same as in Feenstra and Hanson (1996a) where comparative advantage plays a crucial role in the allocation of global production sharing. Moreover, the offshoring cost dampens the comparative advantage of the South, and thus a reduction in offshoring costs help to attract more skill-intensive products to relocate to the South.

Next we characterize the global production sharing when the contracts are incomplete in the South. We also define the "log profit ratio" of the Southern production under different ownership choices, relative to the Southern production with the complete contracts as follows:

$$\begin{aligned} S(z,\beta) &\equiv \frac{1-\alpha}{\alpha}\ln(\pi^S(z,\beta)/\pi^S(z)) \\ &= z\ln\frac{\beta}{1-\beta} + \ln(1-\beta) + \frac{1-\alpha}{\alpha}[\ln(1-\alpha\beta z - \alpha(1-\beta)(1-z)) - \ln(1-\alpha)] \end{aligned} \tag{4}$$

for $\beta \in (0,1)$. This normalization procedure peels off most of common factors in the profit function of $\pi^S(z,\beta)$, such as demand shifter λ, factor prices and offshoring costs, but highlights the key factors for ownership choice. This implies that ownership choice is independent of factor prices, offshoring costs and demand shifters, instead only depends on the skill intensity of the product. Appendix A shows that $S(z,\beta)$ is supermodular in (z,β), concave in z, and strictly concave in β. Thus, for a given value of $z \in [0,1]$, there is a unique maximizer $\beta^*(z) \in [0,1]$, and $\beta^*(z)$ increases in z. Supermodularity implies that optimal revenue share of the Northern innovator is (positively) determined by the skill intensity of the intermediate goods z. This is also the core spirit of the property right theory of firms (Grossman and Hart, 1986; Hart and Moore, 1990). Furthermore, in Appendix B we show that among those offshored products, northern innovators will offshore relatively more skill-intensive intermediate goods through their own affiliates, and outsource less skill-intensive intermediate goods.

Now we discuss the joint decision of the Northern innovator on location and ownership choices, based on the comparison between the log profit ratios of the Northern and the Southern productions with ownership choices ($N(z)$ and $S(z, \beta^O)$ for $O = F, D$). To formally characterize the pattern of global production and ownership structure, we assume:

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

This assumption essentially also rules out the extreme cases that all products are produced in one location.[11] The first part guarantees that the most skill-intensive product $z = 1$ is produced in the North, and the second part guarantees that the least skill-intensive product $z = 0$ is produced in the South.[12] Figure 2 plots three curves of log profit ratios: $N(z), S(z, \beta^D)$, and $S(z, \beta^F)$. The detailed properties of those curves have been discussed in Appendix. Clearly, the optimal choice of the Northern innovator is the upper contour of these three log profit ratios. Based on this assumption, we can show our main proposition:

Proposition 1 *If Assumption 1 holds and three production modes coexist, then there exists two unique cutoffs $(z^*_{FN}(t), z^*_{DF})$, such that the more skill-intensive intermediate goods are produced in the North ($z > z^*_{FN}(t)$), the middle range skill-intensive goods are through FDI offshoring ($z^*_{FN}(t) > z > z^*_{DF}$), and the less skill intensive goods are outsourced to South ($z < z^*_{DF}$). Moreover, as the offshoring cost t decreases, $z^*_{FN}(t)$ increases.*

[11] It is easy to show that $\omega_h < t < \omega_l$ holds under this assumption, and thus $N(z)$ increases in z.

[12] This imposes an up-bound for β^F, i.e., $\beta^F < \widetilde{\beta} \equiv f^{-1}(\omega_l/t)$, where $f(\beta) = \frac{1}{(1-\beta)}\left[\frac{1-\alpha}{1-\alpha(1-\beta)}\right]^{\frac{1-\alpha}{\alpha}}$. The intuition for this upper bound for the Northern innovator's revenue share is that the South supplier will have 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, thus if β^F satisfies this inequality, it also holds for β^D. Note the upbound depends on ω_l and t,thus this assumption is more likely to hold if offshoring cost is low, given ω_l.

The proof in Appendix C is largely in line with Antràs (2005).[13] Figure 2 is also useful to disentangle the role of comparative advantage and incomplete contracts on global production sharing in the integrated framework. Note the horizontal axis presents the log profit ratio of the South production with complete contracts itself. Thus, the upper contour of the curve $N(z)$ and the horizontal axis characterizes the global production sharing with the North-South cutoff $z^*(t)$ in the contractual frictionless world of Feenstra and Hanson (1997), in which the South specializes in less skill-intensive products due to the comparative advantage.

By contrast, the upper contour of these curves $N(z)$, $S(z, \beta^D)$ and $S(z, \beta^F)$ depicts the global production sharing for the world with incomplete contracts in the South. The comparative advantage still plays the role but the incomplete contracts incur to the South both the intensive and extensive margins of efficiency loss; it makes the South's production less profitable and less products are offshored to the South. The North-South cutoff moves to $z^*_{FN}(t)$ and the product range between $z^*_{FN}(t)$ and $z^*(t)$ reflects the extensive margin of the efficiency loss. More importantly, those potential offshorable products are relatively more skill-intensive, and thus this would affect high-skilled labor more. In addition, the area between the upper contour of $S(z, \beta^D)$, $S(z, \beta^F)$ and the horizontal axis reflects the intensive margin of the efficiency loss due to the incomplete contracts.

2.2.1 Ownership liberalization and Reduction in Offshoring Cost

In this subsection, we analyze the impact of ownership liberalization and reduction in offshoring cost on the offshoring pattern. Figure 3 shows that the effect of a decline in offshoring cost can be captured by shifting down the curve of $N(z)$. When the initial offshoring cost is very high, intuitively it is only profitable for the Northern innovator to outsource less skill-intensive products through arms' length contracting because the offshoring cost dampens the comparative advantage of the South. Therefore, no FDI offshoring exists even if foreign ownership is legally allowed. As the offshoring cost declines it becomes profitable to offshore more skill-intensive products to the

[13] Note this proposition only shows the pattern when three production modes coexist, however, under certain conditions, FDI offshoring may not exist. Figure 2 is sufficient for us to do general analysis, as we will show later.

South through foreign affiliates. Moreover, reductions in offshoring costs have a stronger effect on FDI offshoring than on arm's length offshoring. The proof appears in Appendix D, but the intuition is simple: as the revenue elasticities of the offshoring cost is $-\frac{\alpha}{1-\alpha}$, irrespective of firm ownership types. Thus, a decline in offshoring costs increases the intensive margin of each types of firms proportionally. However, a reduction in offshoring cost increases the extensive margin of FDI offshoring but not for arm's length offshoring when both organization forms co-exist (as depicted in Figure 2). Thus, the export share of FDI offshoring increases. In this case, restriction of foreign ownership becomes an important barrier for multinational production.

Governments in developing countries often indeed impose restrictions on foreign ownership for reasons including reducing competition with indigenous firms, promoting technology transfer through joint ventures, and protecting strategic sectors (e.g., Kobrin 1987; Gomes-Casseres 1990). Our model provides a framework to analyze the impact of ownership restriction/liberalization of foreign investment on the South's export structure. Figure 4 shows the case when the Southern government removes the prohibition policy for foreign ownership. If the offshoring cost is sufficient low, the South can benefit substantially from this ownership liberalization reform. First, many more skill-intensive products will be offshored to the South as the cutoff between North-South production moves up to z_{FN}^* from z_{DN}^*, promoting skill-upgrading in southern exports. Second, firms producing products within $[z_{DF}^*, z_{DN}^*]$ raise their profits due to the changes in optimal ownership, indicating positive efficiency gains for the economy.[14] The proposition below summarizes our findings.

Proposition 2 *If the offshoring cost is relatively low, ownership liberalization and further reduction in offshoring cost both increase the North-South production cutoff, i.e., shifting more skill-intensive products to the South through FDI offshoring, and thus the share of FDI offshoring increases.*

[14]Note that the ownership restriction/liberalization policy does not matter if the offshoring cost is very high, as Northern innovators only outsource their less skill-intensive products through arm's length arrangement.

2.3 Skill premium

This section discusses the impact of offshoring on the skill premium in the South. The subscript S is omitted below without causing any confusions. We first show the property of the relative skill demand for a given intermediate good.

Proposition 3 *The relative demand for the high-skilled labor for each product z, 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 wage 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, for given product z, ownership liberalization in foreign investment (increase in β) itself also increases firms' demand for high-skilled labor. Next we define the relative aggregate skill demand in the South as follows:

$$D(q/w, t, \Psi) = \frac{\sum\limits_{\beta^O \in \Psi} \int_{\Omega_\Psi} h(z, \beta^O) dz}{\sum\limits_{\beta^O \in \Psi} \int_{\Omega_\Psi} l(z, \beta^O) dz} \tag{5}$$

where Ψ denotes the ownership choice set, i.e., $\Psi = \{\{\beta^D\}, \{\beta^D, \beta^F\}\}$. $\Omega_\Psi = [0, z^*_{DN}]$ if $\Psi = \{\beta^D\}$ and $\Omega_\Psi = \Omega_D \cup \Omega_F = [0, z^*_{DF}] \cup [z^*_{DF}, z^*_{FN}]$ if $\Psi = \{\beta^D, \beta^F\}$. We can show the following proposition:

Proposition 4 *(1) Reductions in offshoring cost move up the cutoff between North-South production, and in turn increase the relative aggregate skill demand in the South.*
(2) If offshoring cost is relatively low and $0 < \alpha \leq 1/2$, ownership liberalization in foreign investment increases the relative aggregate skill demand in the South.
(3) Ceteris paribus, ownership liberalization and further reduction in offshoring cost increase the skill premium.

Proof appears in Appendix E. The relative aggregate skill demand increases when more skill intensive products are offshored to the South. This mechanism is similar to Feenstra and Hanson (1996a). skill demand. Note the effect of offshoring cost reduction on skill demand exists even with ownership restrictions. However, as the offshoring cost becomes sufficient low, it turns out to be more and more difficult to attract new skill intensive products if outsourcing is the only option. Once the ownership restriction is removed, the relative aggregate skill demand increases through both the extensive and intensive margins: more offshored skill intensive products by foreign affiliates, and the extra skill demand from firms switching from arm's length offshoring to FDI offshoring.

It is easy to show the relative aggregate skill demand has a downward slope given $0 < \alpha \leq 1/2$, and as we assume the relative skill supply is exogenously given, then the skill premium rises as the relative aggregate skill demand shifts up due to the ownership liberalization or further offshoring cost reduction. Thus, Proposition 4 (3) naturally follows.

2.4 The Augmented Mincer Wage Equation

In this subsection, we focus on the demand side for skill premium. First, we obtain the inverse skill demand function from the equation (5) as $ln(q/w) = lnD^{-1}(t, \Psi)$. We have shown that offshoring cost reduction and ownership liberalization increase the skill premium under general conditions in Proposition (4). Next we integrate the inverse skill demand function into an augmented Mincer wage equation. Denoting workers with college degree and above as high-skilled workers, and workers without college degree as low-skilled workers, we can write the classical Mincer wage equation as follows:

$$\ln wage = \alpha_0 + \alpha_1 college + \epsilon \tag{6}$$

where $college$ is an indicator variable for workers with college degree and above. Notice $\alpha_1 = E(\ln wage|college = 1) - E(\ln wage|college = 0) = lnq - \ln w$, and thus indicates the college premium. The last equality holds because lnq and $\ln w$ are the market equilibrium (log) wage for college workers and non-college workers. From the inverse skill demand we can see that the college premium α_1 is a function of offshoring cost and ownership choice set. Thus, we obtain the augmented mincer wage equation as follows

$$\ln wage = \alpha_0 + \alpha_1(t, \Psi)college + \epsilon \tag{7}$$

This augmented Mincer wage regression provides a direct empirical specification to test our model predictions (Proposition 4). Our model implies that the coefficients of the interaction term of the offshoring cost reduction and ownership liberalization with the college indicator should be both positive. This reduced form approach is simple and attempting, however it does not tell us whether the effects of offshoring cost reduction and ownership liberalization on skill premium are through their effects on the size of offshoring and changes in offshoring organizational forms. It also does not distinguish the differential effects of two types of offshoring on skill premium. To enrich our understanding we propose a two-stage identification strategy based on the local-labor market approach. Next we discuss the identification strategy in detail.

2.5 Identification Strategy

Our identification strategy follows the local-labor-market approach that maps trade shocks to labor market outcomes, in particular the skill premium (Autor et al., 2013). We use the rich spatial variations in regional exposure to FDI offshoring and arm's length offshoring along the trade and ownership liberalization in the last two decades in China. More specifically, our identification strategy consists of two stages. In the first stage, we estimate the impact of offshoring cost reduction and ownership liberalization on regional (and industrial) distribution of FDI and arm's length offshoring.

$$lnR^O = lnR^O(t, \Psi), \text{where } O \in \{D, F\}. \tag{8}$$

where R^O is the regional (and industrial) export revenue for firm ownership O. Our model proposition (2) implies that the offshoring cost reduction and ownership liberalization should have a stronger positive effect on FDI offshoring than on arm's length outsourcing.

In the second stage, we estimate the augmented Mincer regression with the interaction term of college indicator and the regional total offshoring (R) and the share of FDI offshoring (R^F/R) (or equivalently, regional FDI and arm's length offshoring respectively), i.e.,

$$\ln wage = \alpha_0 + \alpha_1(R, R^F/R)college + \epsilon \tag{9}$$

This identification strategy directly tests two main propositions (2) and (4) of our model. Moreover, this approach is more structural. It first shows the effect of offshoring cost reduction and ownership liberalization on offshoring, and the second stage identifies which type of offshoring matters for skill premium. In addition, one important concern in empirical estimation is the positive selection bias of multinational companies, which tend to choose regions with abundant high-quality labors when they offshore. Our two-stage procedure offers a natural approach to deal with this selection issue, because we can construct instrument variables for the endogenous variables ($R, R^F/R$) by using the predicted values from the first stage regression. We will discuss this in detail later.

Note our identification method takes the advantage of rich spatial variations in exposure to trade shocks, and thus one implicit assumption is the low labor mobility across regions. If labor is free mobile across provinces, trade may affect workers without its consequences being identifiable at the regional level. The literature on regional adjustment to labor-market shocks suggests that mobility responses to labor demand shocks across regions are slow and limited, particularly for developing countries such as China.[15] China has a *Hukou* household registration system that imposes large cost of working and living outside one's *Hukou* registration region. According to Tombe and Zhu (2015)'s estimate for 2000, the average cost of inter-province migration is close to one year of annual income and the migration cost only slightly decreased between 2000 and 2005. An indication of how tightly migration costs bind is the large regional income disparity across provinces. In our data, the average wage ratio of the 90th and 10th percentile provinces for non-college and college workers in urban China was 2.95 and 2.88 in 1992 respectively (the cor-

[15]Recently many studies use the local market approach to explore the labor adjustment to trade shocks in advanced economy such as U.S., e.g., Autor et al. (2013), David et al. (2015), and Acemoglu et al. (2014), and developing countries including Brazil and China, e.g., Dix-Carneiro and Kovak (2015) and Han et al. (2011).

responding ratio for U.S. state is around 1.5 on average for two types of labor). This large regional income disparity did not decline but rather slightly rose in 2006. The wage ratio of the 90th and 10th percentile provinces for non-college and college workers increased to 2.96 and 3.01 in 2006 respectively. This indicates the labor mobility across provinces in China is not sufficient and thus enable us to use the regional variations to identify the impact of trade on labor market outcomes.

3 Empirical Analysis

3.1 Data

We collect three comprehensive data sources for empirical analysis: the ownership liberalization policy measure at industrial level constructed by ourselves (1995-2007), Chinese customs trade data (1992-2008), and the Chinese Urban Household Surveys (CUHS 1992-2006). Both the trade and labor data sets cover mainland China's provinces except Tibet due to data missing in CUHS.

The experiment of ownership liberalization for foreign investment in China provides a unique opportunity to test our model. As early as 1979, the Chinese government started to encourage foreign direct investment through joint ventures, which was considered as an effective way to learn management skills and technology. However, Wholly foreign ownership was restricted or prohibited in many manufacturing industries until the late 1990s prior to the accession to WTO. For example, washing machines, refrigerators, air conditioners were on the restriction list for foreign ownership in 1995, according to the Catalogue for the Guidance of Foreign Investment Industries (CGFII) published by the National Development and Reform Commission. This ownership restriction industry policy was against the spirit of the WTO Agreement on Trade-Related Investment Measures (TRIMs), which precludes the WTO members from imposing restrictions or distortions on foreign investment. Thus, the government undertook a major legal and economic reform in foreign investment in late 1990s to remove foreign investment barriers. One major effort is to revise the CGFII to relax ownership controls gradually by increasing the encouragement coverage and decreasing the restriction coverage for foreign ownership. As documented by Sheng and Yang (2016), both the expansion of encouragement coverage and the reduction in restriction/prohibition coverage were the most significant around 2001. These policy reforms resulted in significant changes in the composition of foreign capital inflows to China. Joint ventures played a dominant role before 2001, but the share of wholly foreign owned firms has increased to 78% by 2008.

We construct a unique measure of ownership liberalization using the official government list (CGFII) of industries that were encouraged, and restricted (or prohibited) for foreign investment. The CGFII was first published in 1995 and was revised subsequently in 1997, 2002, 2004, and 2007. In encouraged industries, foreign investors were given more freedom to choose their ownership structures and enjoyed other advantages, such as preferable corporate tax rates, low land costs, and duty-free imported inputs. By contrast, the Chinese government imposed stringent restrictions on ownership structures and high entry costs for foreign investors in restricted or prohibited industries. For subsequent regression analysis, we construct two proxies for ownership liberalization at the industry level: an encouragement policy indicator and a restriction (including 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's list of encouragement (or restriction), i.e., $EP_{it} = 1$ (or $RP_{it} = 1$); otherwise, we assign the value of 0 to that industry. Therefore, the reference group consists of industries without policy interventions, and these two policy indicators capture the effects of ownership regulations.We also assume that there are no policy changes until a formal revision is announced in the published Catalogue. [16]

The trade data set 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. We use the processing export to measure the size of offshoring, and

[16]Please see Sheng and Yang (2016) for a detailed discussion on our construction method, the advantage and limitation of the indicator variable approach, the exogeneity of the ownership policy changes, and the pattern of over time changes.

the processing export by wholly foreign owned firms to measure FDI offshoring, and processing exports by other firms are used to measure arm's length offshoring. We also treat the high-income countries classified by World Bank as the North country for the benchmark analysis.[17] Processing exports play a major role in Chinas international trade, accounting for an average of 56 percent of the countrys total exports from 1992 to 2008, and about 90 percent exported to high-income countries. Table 1 presents the summary statistics of processing exports.

The CUHS, conducted by China's National Bureau of Statistics (NBS), 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 sector) 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.

4 Empirical Evidence

4.1 Comparison of Skill Content

In this section, we first present evidence for the skill content difference between FDI offshoring and arm's length offshoring. Figure 5 (a) presents the evolution of average skill intensity of two types of processing exports for the period 1992-2008. The average skill intensity is defined as the weighted average of industrial skill intensity, using the industrial share of processing exports

[17] Our definition of high-income countries follows the World Bank's standard classification, including 66 countries. 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. For robustness check we also use all China's trade partners as the North country. Most of empirical results hold for both samples.

as the weights.[18] The measure of skill intensity z_i for industry i is defined as the employment share of workers with college degrees or above in total industrial employment, using the industrial employment information from Chinese National Industry Census 1995 (CNIC1995).[19] It clearly shows that FDI offshoring is more skill intensive than arm's length offshoring, and there has been significant skill upgrading in the processing exports since 1992.

Next, we examine the distributions in skill intensity across the two types of offshoring. Figure 5(b) presents the distributions of processing exports by firm ownership types in 1992 and 2008.[20] This figure reveals two important messages. First, the distribution of FDI processing export is more skewed toward skill-intensive sectors than that of arm's length processing exports. In other words, FDI processing exports first-order stochastically dominate 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 significant skill upgrading in the processing exports. Note this feature is also more significant for FDI processing exports.

More formally, following Delgado et al. (2002) we adopt the non-parametric Kolmogorov-Smirnov test for the first-order stochastic dominance. We first perform a two sided Kolmogorov-Smirnov test to examine the equality of the two distributions, i.e., $G^F(z) = G^D(z)$. If the equality hypothesis is rejected, we then use a one-sided test to examine the first order stochastic dominance, i.e., $G^F(z) \leq G^D(z)$. If we fail to reject this hypothesis and given $G^F(z) \neq G^D(z)$ (obtained from the first step), we conclude that $G^F(z) < G^D(z)$.

The Kolmogorov-Smirnov test requires independent identical sample, while we have sampling data for 1992-2008 and they may have auto-correlations across years. Thus, we run the test year

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[18]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 $O = F, D$. 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.

[19]We convert both the skill intensity measure at Chinese Standard Industrial Classification 1994 (CSIC1994) at 3 digits level and trade data based on 6 digits of 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.2. 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. As a robustness check, we use the skill intensity measure from the National Economic Census 2004 (NEC 2004). The results remain the same.

[20]The empirical distribution $\widehat{G}^O(z)$ for $O = F, D$ 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.

by year. Panel A in Table 2 presents the p-value for testing results in which a small number indicates rejecting the hypotheses. The two-sided test shows that it rejects the null for years 1997-2008 at 5 percent significance level but not for earlier years, and the one-sided test does not reject the null for all years in our sample. Thus, we conclude that FDI processing exports have been more skill intensive than arm's length processing export since 1997. It is reasonable that the two-sided test fails to reject the null for years before 1997, because the offshoring cost was high and foreign ownership was restricted, only a few foreign-owned firms entered. Thus, the distributions are not statistically different from each other. As the offshoring cost declined and the restrictions on foreign ownership were gradually removed, more intermediate goods were offshored through foreign-owned firms, and their distributional differences became statistically significant.

This two-step testing procedure can be applied to testing for skill upgrading in processing exports for each type of firms. Panel B in Table 2 shows the results for each five-year interval during 1992 and 2007. The two-sided test rejects the null at 5 percent significance level, 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 through arm's length only after 1997. Thus, the skill upgrading must be similar for all firms initially, but later it becomes more substantial in FDI processing exports.

In the end, we calculate the contribution of FDI processing export to the total skill content in total processing exports, as the ratio of the skill content in the FDI processing exports to the skill content of the total processing export, i.e., $skshr_t^F = \frac{\sum_i z_i y_{i,t}^F}{\sum_i z_i y_{i,t}} = \frac{\tilde{z}^F}{\tilde{z}} \frac{\sum_i y_{i,t}^F}{\sum_i y_{i,t}} = Z^F * S_t^F$ where $Z^F = \tilde{z}^O/\tilde{z}$ is the relative average skill intensity, and $S_t^F = \frac{\sum_i y_{i,t}^F}{\sum_i y_{i,t}}$ is the value share of FDI processing exports. This implies that the contribution of FDI processing exports to skill content can be decomposed into two parts: the relative average skill intensity and its share in processing exports. This exercise shows that its contribution has risen from about 12 percent to about 70 percent of total skill content of processing exports, and most of them comes from the rising size of FDI processing exports. Thus, FDI becomes the major contributor of the skill content in processing exports.[21]

4.2 The determinants of offshoring and its ownership structure

So far we have shown that FDI processing exports are more skill intensive than arm's length offshoring. Thus, the distribution of FDI processing exports has important implications for the difference in regional skill demand and skill premium. Next we study the determinants of regional and industrial distribution of two types of processing exports. In particular, we test whether offshoring cost reduction and ownership liberalization increase the processing exports, particularly through FDI, as shown in our Proposition (2).

To develop the regression specification, we denote our dependent variable $ln(R_{oijt})$ as the log value of processing exports of organizational form o, in industry i, province j, and year t. We interact the ownership indicator variable FDI_{oijt} with the encouragement policy (EP_{it}), the restriction policy (RP_{it}), and measures of offshoring cost reduction ($offcost_{jt}$), obtaining the regression:

$$\begin{aligned} ln(R_{oijt}) = {} & \theta_0 + \theta_1 FDI_{oijt} + \alpha_1 EP_{it} + \alpha_2 RP_{it} + \alpha_3 offcost_{jt} \\ & + (\beta_1 EP_{it} + \beta_2 RP_{it} + \beta_3 offcost_{jt}) \times FDI_{oijt} + \gamma' X + \xi_i + \xi_j + \xi_t + \epsilon_{oijt} \end{aligned} \quad (10)$$

We use two proxies to measure the reduction in offshoring cost. The first is the cumulative number of national policy zones. Recent studies, including Wang (2013), Li (2013) and Wang and Wei (2010), show that policy zones in China promoted foreign investment and processing trade by reducing offshoring costs.[22] For the second one, we follow Limão and Venables (2001) to use

[21] Due to the data limitation, we only consider the "between"industrial skill upgrading, but not the "within"industrial skill upgrading such as in Hsieh and Woo (2005). However, our analysis on skill content is relatively conservative as the employment share of skilled workers in foreign owned firms is relatively higher than other firms by using the National Economic Census in 2004 (Chen et al., 2011). We also match the census data with the Chinese firm level customs data to identify processing firms. We find that the employment share of college graduates in wholly foreign owned enterprise is 6 percent higher than that of others. This snapshot of the skill comparison is largely consistent with the international evidence that FDI is relatively more skill and capital intensive.

[22] China established special economic zones for export in coastal provinces starting in the early 1980s, and later

infrastructure-the (log) density of highway and railway-to approximate offshoring costs reduction.

This specification estimates the differential effects of industrial policy and offshoring cost reduction on the FDI and outsourcing processing exports, which are the main testable hypotheses from the model. The linear coefficients α's shed lights on the effects of the key variables on outsourcing processing export varieties, and the interaction coefficients β's capture the effects of these variables on FDI processing exports relative to outsourcing processing exports. We focus on the signs and magnitudes of β's and expect $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 > 0$. We also expect the total effects of encouragement (restriction) policy and offshoring cost reduction on FDI processing exports to be positive (negative). Although the model provides implications for α's, empirically relevant counter-acting forces are not analyzed in the model. For example, although competition from the entrance of foreign affiliates after ownership liberalization could reduce outsourcing processing exports, learning effects associated with knowledge spillovers from FOEs tend to neutralize the competition effect (Javorcik, 2004). Therefore, we should be cautious in interpreting the estimates for α's, because they empirically capture the total effects of those opposing forces.

For control variables in X, following Romalis (2004), this regression also includes the factor endowment variables K_{jt} and L_{jt} interacted with industry-specific factor intensity h_i and k_i.[23] To control for the role of institutions, we follow Nunn (2007) to include the interaction term of industry-specific contract intensity $Contr_i$ and the regional contract environment $Inst_j$.[24] To avoid

expanded into inland provinces. These policy zones include Economic and Technological Development Zone, High-Tech Development Area, Bonded Area, Export Processing Zone, and other types. Companies in these zones enjoy various advantages, including low corporate tax rate, duty-free imported inputs, absence of import and export quotas, low land costs, and non-payment of property tax in the first several years. They are also prioritized in streamlined customs clearance and 24-hour customs support. The central government authorized the establishment of national policy zones, and this process is arguably an exogenous one that is beyond the control of provincial governments. The data source is the China Development Zone Review Announcement Catalogue (NDRC, 2007).

[23] Skill intensity is the industry-specific college employment share, and we use the ratio of fixed asset investment to output at industrial level to proxy the capital intensity. Both variables are constructed based on the data from the Chinese National Industrial Census in 1995. The skill labor endowment is the the share of college workers in the population aged above 6, and the capital endowment is the ratio of capital to output. We are grateful to Chongen Bai for sharing this data with us.

[24] Following the idea of Nunn (2007), the industry-specific contract intensity is proxied by the inputs share of the relationship specific intermediates based on the Chinese input-output table (Feenstra et al., 2013). We are very grateful to Hong Ma for sharing this Nunn index with us. The measure of provincial contract environment is from the survey of doing business in 30 provincial capitals in China, published by World Bank (2008). Specifically, we use the "court cost" variable in their data, 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

the potential contemporaneous correlations between the error term and provincial variables such as infrastructure, national policy zones, skill labor endowment, and capital stock, we use one-year lagged values. For easy interpretation, all variables except indicator variables are de-meaned before we compute the interaction term. ξ_i, ξ_j and ξ_t are used to control for industry, province and year fixed effects. To control for unobserved time-varying provincial variables such as local government policies and agglomeration, we also control for province-year fixed effect as an alternative specification, at the cost of losing the estimates for the observed province time-varying variables, such as the measures of offshoring cost reduction.

We begin with a simple specification in Table 3 that only includes the interaction terms of organizational form with key variables of ownership liberalization policy and the offshoring cost, and fixed effects for organizational form, province, industry and year. The negative coefficient for the FDI indicator suggests that on average FDI processing exports are less than that of arm's length processing exports during the sample period, reflecting the fact that for many years the volume of outsourcing processing exports exceeded that of FDI. Overall, both the encouragement and restriction policies do not have significant effect on outsourcing processing exports. The offshoring cost reduction measured as policy zones and infrastructure increases outsourcing exports.

The most important empirical findings are presented by the four interaction terms with FDI indicator in Column 1, which are designed to test the key model prediction (Proposition 2). As expected, the coefficient on $FDI \times Encouragment\ policy$ is statistically positive, indicating that relaxing ownership restrictions increase FDI processing exports. By contrast, restriction policies significantly reduce processing exports of FDI but not for outsourcing. Finally, the positive coefficients on $FDI \times Policy\ zones$ and $FDI \times Infrastructure$ indicate that lower offshoring cost increase processing exports of FDI more than those of outsourcing.

The second column in Table 3 presents the results with controls for the interaction terms of industry-specific factor intensities and provincial factor endowments. The positive coefficients of those interaction terms indicate the role of regional comparative advantage. Regions with

upholding contracts between firms. For convenience of interpretation, we construct a court efficiency measure, which equals 0.5 minus the variable court cost.

more abundant skilled labor or capital exports more skill intensive or capital intensive products. Provinces with better contract environment exports more contract-intensive products, and the magnitude is also similar to the findings in (Feenstra et al., 2013).[25]

Column 3 includes the province-year pair fixed effect to control for other unobserved province-year varying factors. Thus, the province-year varying variables including infrastructure and national policy zones are dropped due to collinearity. Our main conclusions of ownership policy and offshoring cost reduction still hold. Quantitatively, the encouragement policy increases FDI processing exports by about 24 percent, and the restriction policy reduces FDI processing export by about 44 percent, compared with industries without policy interventions. Those ownership policies do not significant effect on arm's length processing exports. As for infrastructure, one percent of increase in highway and railway density increases 0.21 percent more on FDI processing exports than arm's length processing exports. One additional national policy zone increases 8 percent more on FDI processing exports than arm's length processing exports.[26]

Table 1 shows that the shares of FDI in processing export are relatively higher in high-skill intensive industries, particularly in the years around 2001 when China got access to WTO. Thus, next we further investigate whether the increase in exports through FDI is mainly from the high-skill intensive industries. Column 4 and 5 in Table 3 present estimation results for the specification (10) separately for high and low-skill intensive industries with the sample mean as the threshold. On the basis of the interaction terms, we find that the industrial encouragement and restriction policies exert much stronger effects on FDI processing exports relative to outsourcing processing exports in high skill intensive industries compared with low skill intensive industries. Moreover, improvements in infrastructure and the establishment of policy zones also help FDI processing exports more in high skill intensive industries. These findings are broadly consistent with model

[25]The only noticeable change is the slightly decline in the coefficient of policy zones, making it insignificant. However, the effect of infrastructure on outsourcing processing exports remains similarly.

[26]One caveat of this log transformation in the basic specification (10) is that it dropped all zero export value. This may leave out useful information reported in the data or bring potential bias due to the heteroskedastic multiplicative error. We follow Silva and Tenreyro (2006) to adopt the Poisson pseudo-maximum likelihood (PPML) estimation, which uses the level of trade flow as the dependent variable so that it can include zeroes. The estimation results show that the relative stronger effects of ownership policy and offshoring cost reduction on FDI processing exports remain to hold qualitatively.

predictions.[27]

4.3 Determinants of College Premium

Previous sections have shown the skill intensity difference across FDI and outsourcing processing exports, and their regional and industrial determinants. In this section we turn to the second stage of our identification strategy, and explore the effect of the regional distribution of two types of processing exports on the skill premium by using the augmented Mincer wage regression in a local labor market setting.

The classic Mincer regression models the log real wage as a function of workers' education and years of potential labor market experience. Thus, the dependent variable for analysis, $\ln(wage_{mjt})$, is the log real annual wage for individual m in province j and year t. We use college indicator ($coll_{mjt}$) as the basic measure of education, and thus the coefficient of the college indicator reflects the college premium. Because of the local labor market frictions, the college premium may be different due to differential regional exposures to globalization and other factors such as skill biased technology. The augmented Mincer earning regression models the college premium as a function of factors that affect the regional skill demand. Thus, we interact the college indicator with those relevant regional (provincial) variables, including the ratio of processing exports to industrial outputs, denoted as $proexratio_{jt}$, and the FDI processing exports share, denoted $feshr_{jt}$, and obtain the following augmented Mincer regression:[28]

$$ln(wage_{mjt}) = \alpha_0 + [\beta_0 + \beta_1 proexratio_{jt} + \beta_2 feshr_{jt} + \beta_3 X_{jt}] \times coll_{mjt} + \gamma G_{mjt} + \delta_{jt} + \epsilon_{mjt} \quad (11)$$

where X_{jt} are other provincial variables associated with the college premium. G_{mjt} are other per-

[27]Interestingly, we find that the encouragement policy also has a positive effect on outsourcing processing exports in high skill intensive industries, which is likely due to the spillover effect from FDI processing exports or other preferable treatment in encouragement policy. Similarly we can also explain that the restriction policy has a negative impact on outsourcing processing exports in low skill intensive industries.

[28]An alternative specification is to include the ratios of FDI (or arm's length) processing exports to industrial outputs. However, we prefer the benchmark specification because it reflects both the scale effect and composition effect of the processing exports. Moreover, we can also directly compare the differential impacts on skill premium of processing exports and ordinary exports.

sonal characteristics including gender, experience, squared experience and the indicator of state owned sector. Province-year pair dummies, i.e., δ_{jt}, are used to capture the province-year differences in the determinants of wage income. Province-year cluster robust standard deviation is adopted to control for the sample dependence. Our theory suggests that regions that have more processing exports and higher share of foreign-owned firms have higher skill demand and higher college premium, thus we would expect β_1 and β_2 are positive.

Table 4 presents the summary statistics of household characteristics and related provincial variables. Table 5 column (1) begins with a simple Mincer regression 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, 2014).

Next we include the interaction terms of the college indicator with the ratio of ordinary exports and processing exports to industrial output and the share of FDI processing exports. The column (2) shows that both the size of processing exports and the share of FDI processing exports are significant for the college premium, which are consistent with our theory. However, the ordinary exports have the positive coefficient but the effect is insignificant. Thus, it does not support the Stolper-Samuelson theorem which argues that the relative wage of unskilled workers should increase as the low-skilled abundant country exports more low-skill intensive products.

The regression above 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 aggregate output to measure the skilled-biased technology, and capital-to-output ratio to capture capital-skill complementarity.[29]Table 5 column (3) presents the result with those additional controls. Our key variables, the processing exports ratio and the share of FDI processing exports, are

[29]As a robustness check, we also include the import share of equipment to capture the imported skilled biased technology, following Eaton and Kortum (2001) and Burstein et al. (2011). The results are largely unchanged.

still significantly positive. However, both alternative theories are not supported by the data. The R&D expenditure ratio and capital-to-output ratio both have the positive sign but the effects are not significant. Thus, overall our theory is the most possible explanation for the rising college premium in China.[30]

One concern is that our key variable processing exports ratio and the share of FDI processing exports may be endogenous to labor market conditions. For example, processing firms particular foreign affiliates tend to choose regions with abundant high-quality labors. This selection implies a positive bias in the OLS estimates. Inspired by Frankel and Romer (1999), we adopt a two-stage procedure to deal with the endogeneity issue. First, we construct the predicted values of processing exports ratio, and the share of FDI processing exports from the regression of the determinants of the processing exports (regression (10)) as follows:

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

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

where $\widehat{lnR}_{oijt}$ is the predicted log value of processing exports from the regression (10), based on the result in column (3) of Table 3. Then we use these predicted values as the instruments for processing exports ratio and the share of FDI processing exports in the augmented Mincer regression. Those predicted values constitute legitimate instruments because the key determinants of processing exports by types, ownership liberalization policies and infrastructure, are plausibly not correlated with individual households' characteristics. We present the scatter plots of the actual and predicted values of processing export ratio and the share of FDI processing export in Figure F.1 in Appendix F.1, and they show significant correlations between the actual and predicted values of the variables of interest. Notice this manual two-stage regression generates consistent estimates

[30]This result is robust if we adopt a two-step regression, in which we first get a province panel of estimates of college premia by estimating Mincer regression for each province at each year, and then regress the imputed college premium on those provincial variables in Table 5. We prefer the augmented Mincer regression because it allows us to control for personal characteristics and to estimate the two-step regression in one step.

of coefficients, but their estimated standard errors are incorrect. Thus, We use non-parametric bootstrap method to correct the standard errors (Angrist and Pischke, 2008).

Column (4)-(5) in Table 5 report the results using instrument variables. We use the F-test for weak instruments, and the F-test statistics in the first stage are all above the Stock-Yogo criteria of 10, rejecting the notion of weak instruments. The IV estimates for two key variables are still significant positive, and the magnitudes are also close to the OLS estimate. Based on the IV estimates in Column (5) in Table 5, one percentage point increase in the ratio of processing exports to industrial output and the share of FDI processing exports are associated with about 0.789 and 0.196 percentage point increase in the college premium (log wage differential), respectively. Because China's processing export ratio and the share of FDI processing exports have increased by 5.8 and 25 percentage points from 2000 to 2006, each of them contributed 4.6 and 4.9 percentage points, respectively, to the increase in the college wage premium. Overall, they account for 63 percent of the total increase in the college wage premium between 2000 and 2006. Because the 73 percent of growth of total processing export is attributed to FDI during this period, our back-of-envelope calculation implies that overall the FDI processing exports contributed about 55 percent in the increase of the college premium in the manufacturing sector in Urban China.

Next we conduct various sensitivity analysis on the determinants of skill premium. The first concern is the omitted ability problem which might lead to positive bias in college premium. Due to the data limitation, these well-known instruments for the college indicator and schooling years are not available.[31] To alleviate this concern, we use the cohort whose potential college education was during the Cultural Revolution (1966-1976) for a robustness check. As the National Higher Education Entrance Examination has been abolished during the Cultural Revolution, the selection of college education in this period was more political oriented and less depended on personal ability for education and potential earning. Park et al. (2015) find that the Cultural Revolution was a great equalizer of educational access, and among city-cohorts affected during the Cultural Revolution

[31]The CUHS does not contain the information of birthday and (the birth) family background of the individuals, we can not use birthday, parents education level or birth family size as instruments. Another widely used instrument, the distance to nearby colleges or its variants, is also not available because the individual birth place is not surveyed in the CUHS.

years, childrens educational attainment became much less correlated with that of their parents compared with other cohorts prior or after the Cultural Revolution. To proceed this exercise, we keep only the birth cohort during 1947 and 1957 and rerun our regression (11). Column 1 in Table (6) shows that the two key interaction terms of college indicator with the ratio of processing exports and the share of FDI processing exports remain positive significant and their magnitudes are also close to our baseline estimates, indicating the omitted ability variable might not affect our results significantly.[32]

Second, women participation rate has been declining and the gender gap was rising during the sample period (Ge and Yang, 2014). To avoid the potential complication of the composition change of labor force, we use the male sample only, and our results are still robust as shown in Column 2 in Table (6). Third, the quality of college education might change over time. In particular, the education system itself has been reconstructed from the era of central planning economy to the market economy. It is difficult to obtain a consistent measure of educational quality for cohorts whose birth year went back to as early as 1946, as the education system has experienced significant reform in the last 60 years. We use the ratio of college teachers to college students at province level to proxy the provincial quality difference of college education. Column 3 shows that the results for our key variables are similar to the baseline estimates, and the quality of education has a neglectable negative effect on the college premium.[33] Fourth, we also use the sample of processing export to all China's trade partners and achieve the similar results as shown in Column 4. This implies our results are not sensitive to the selection of high-income trade partners.

Finally, we also use years of school as a measure of skills, and explore the impact of the processing exports ratio and the share of FDI processing exports on the return to education. We find that the effect of the size of processing exports and the share of FDI processing exports are still positively significant as shown in Table F.1. Moreover, quantitatively the magnitudes are also

[32] Notice the estimate of the college indicator is smaller than the baseline estimate. This gap indicates a lower bound of the potential bias due to the omitted ability as the lower return to college in Cultural Revolution also reflects the sever destructive effects on college eduction.

[33] The negative sign reflects the fact that the college teacher-student ratio has been in a declining trend while the college premium is rising.

close to our baseline estimate of college premium if we multiply the estimated rate of return to schooling years by a factor of 4.

5 Conclusion

This paper proposes a new mechanism linking offshoring and wage inequality in developing countries and test the model using a natural experiment of ownership liberalization in China. It offers robust evidence that FDI processing exports are more skill intensive than arm's length processing exports. A reduction in offshoring costs and ownership liberalization shift more skill intensive production to foreign affiliates in the South, which in turn increases the relative demand for high-skilled labor. The augmented Mincer regression shows that FDI processing exports is the main driving force behind the rising college premium between 2000 and 2006. This finding is robust to alternative specifications and theories.

Our finding has important policy implications for developing countries. Conventional wisdom suggests that developing countries should encourage joint ownership between the South and the North in order to create technology spillovers from the North through joint production. Our analysis implies that the multinationals jointly decide on their strategies for offshoring, ownership structure, and skill demand. Thus, if the South imposes foreign ownership restrictions, more skill-intensive products would remain in the North, and only less skill-intensive products are offshored to the South. This policy intervention would lower the demand for high-skilled labor and therefore impedes economic growth in the South.

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Table 1: Summary Statistics of China's Processing Exports

	Processing exports		Share in processing exports		FDI's share in		
Year	Value (Billion dollar)	Share in total exports	High-skill industries	High-income trade partners	All	Low-skill industries	High-skill industries
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1992	39	0.53	0.36	0.95	0.10	0.09	0.13
1993	44	0.54	0.36	0.94	0.15	0.14	0.18
1994	57	0.51	0.41	0.92	0.19	0.17	0.21
1995	73	0.53	0.47	0.90	0.22	0.21	0.23
1996	84	0.60	0.46	0.90	0.26	0.24	0.29
1997	99	0.58	0.49	0.89	0.29	0.26	0.32
1998	104	0.60	0.51	0.90	0.32	0.28	0.36
1999	111	0.59	0.54	0.90	0.36	0.31	0.40
2000	137	0.58	0.58	0.90	0.38	0.33	0.42
2001	147	0.58	0.60	0.91	0.41	0.35	0.44
2002	179	0.57	0.65	0.89	0.46	0.40	0.50
2003	241	0.57	0.71	0.91	0.52	0.43	0.56
2004	327	0.57	0.75	0.90	0.56	0.46	0.59
2005	415	0.56	0.77	0.89	0.60	0.51	0.62
2006	509	0.54	0.79	0.88	0.63	0.55	0.65
2007	616	0.51	0.80	0.87	0.64	0.56	0.65
2008	674	0.48	0.81	0.84	0.64	0.58	0.66

Note: We use the employment share of college workers in 1995 to measure skill intensity at the industrial level; and, high-skill industries denote skill intensity above the sample mean.

Table 2: The Kolmogorov-Smirnov Test for Stochastic Dominance

Panel A: Skill difference between FDI and Arm's length processing exports

	Two-sided test	One-sided test
P-value	No difference between two distributions	FDI weakly dominates Arm's length
1992	0.06	1.00
1993	0.18	1.00
1994	0.26	1.00
1995	0.08	1.00
1996	0.07	1.00
1997	0.02	1.00
1998	0.01	1.00
1999	0.00	1.00
2000	0.00	1.00
2001	0.00	1.00
2002	0.00	1.00
2003	0.00	1.00
2004	0.00	1.00
2005	0.00	1.00
2006	0.00	1.00
2007	0.00	1.00
2008	0.00	1.00

Panel B: Skill upgrading for FDI and Arm's length processing exports

		Two-sided test	One-sided test
	P-value	No difference between two distributions of t and (t+5)	The distribution in (t+5) weakly dominates the one in t
Arm's length processing exports	1992-1997	0.03	1.00
	1997-2002	0.01	1.00
	2002-2007	0.00	1.00
FDI processing exports	1992-1997	0.02	1.00
	1997-2002	0.00	1.00
	2002-2007	0.00	1.00

Note: P-value is computed based on the limiting distribution of the Kolmogorov-Smirnov test statistics..

Table 3: Determinants of China's Processing Exports

	All industries			High-skill industries	Low-skill industries
VARIABLES	(1)	(2)[a]	(3)	(4)	(5)
FDI indicator	-1.174***	-1.214***	-1.219***	-1.769***	-1.148***
	(0.060)	(0.060)	(0.060)	(0.122)	(0.061)
Enc. policy	0.068	0.078	0.093	0.263**	-0.095
	(0.073)	(0.072)	(0.073)	(0.112)	(0.093)
Res. policy	-0.077	-0.056	-0.057	0.063	-0.383***
	(0.059)	(0.056)	(0.055)	(0.066)	(0.089)
Natl policy zones	0.025**	0.019			
	(0.011)	(0.012)			
Infrastructure	0.278**	0.319***			
	(0.111)	(0.111)			
FDI × Enc. policy	0.244***	0.244***	0.244***	0.751***	0.180***
	(0.055)	(0.055)	(0.055)	(0.115)	(0.059)
FDI × Res. policy	-0.448***	-0.441***	-0.435***	-0.520***	-0.156**
	(0.060)	(0.060)	(0.060)	(0.079)	(0.076)
FDI × Natl. zones	0.078***	0.082***	0.080***	0.088***	0.075***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
FDI × Infrastructure	0.205**	0.186**	0.209**	0.301**	0.191*
	(0.089)	(0.091)	(0.093)	(0.118)	(0.098)
Skill intensity × college share		0.857***	0.862***	0.491***	0.569*
		(0.081)	(0.081)	(0.102)	(0.293)
Capital intensity × capital/output		0.006**	0.006**	0.004	0.004
		(0.003)	(0.003)	(0.004)	(0.003)
Contract dependent × institution		0.140***	0.141***	0.166***	0.152***
		(0.012)	(0.012)	(0.014)	(0.017)
Industrial fixed effect	+	+	+	+	+
Provincial and year fixed effect	+	+			
Province-year fixed effect			+	+	+
Observations	36,871	36,158	36,158	15,839	20,319
R-squared	0.512	0.521	0.532	0.521	0.564

Note: The dependent variable is log(processing exports value). The sample covers China's processing exports to high-income countries. The panel covers 29 provinces and 112 industries in 1992-2007. Province-year pair cluster robust standard errors are in parentheses. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

[a] Provincial-year varying variables such as college share and capital output ratio are included in the regression, but their coefficients are insignificant and thus not reported in the table.

Table 4: Summary Statistics

Panel A: Households Characteristics					
Variables	Obs	Mean	Std. Dev.	Min	Max
Ln(wage)	156,658	8.86	0.76	2.09	12.43
College	156,658	0.16	0.37	0	1
Schooling years	156,658	11.17	2.48	0	18
Age	156,658	39.35	8.94	16	60
Experience	156,658	21.75	9.29	0	44
Sex	156,658	0.45	0.50	0	1
State sector indicator	156,658	0.70	0.46	0	1
Panel B: Provincial variables					
Ratio of processing exports to industrial output[a]	435	0.04	0.08	0.00	0.47
Share of FDI processing exports[a]	435	0.19	0.21	0.00	0.82
Ratio of processing exports to industrial output[b]	435	0.05	0.09	0.00	0.49
Share of FDI processing exports[b]	435	0.19	0.21	0.00	0.82
Ratio of ordinary exports to industrial output	435	0.07	0.05	0.01	0.49
K/Y	420	1.44	0.43	0.67	2.78
Share of persons with college degree in population aged above 5	435	0.04	0.04	0.00	0.29
R&D/Y	435	0.01	0.01	0.00	0.09
Court efficiency	435	0.28	0.09	0.08	0.41
Infrastructure (log(highways+railways)/area)	433	-1.32	0.85	-4.10	0.37
The cumulative number of national policy zones	435	5.59	4.90	0	27

[a] Processing exports to high-income destinations
[b] Processing exports to all countries

Table 5: Determinants of Manufacturing College Premium in Urban China: 1992-2006

	OLS			IV[a]	
Independent variables	(1)	(2)	(3)	(4)	(5)
College	0.350***	0.244***	0.208***	0.252***	0.221***
	(0.009)	(0.014)	(0.029)	(0.008)	(0.022)
College indicator interaction terms					
College × Processing exports ratio		0.668***	0.723***	0.774***	0.789***
		(0.169)	(0.179)	(0.157)	(0.157)
College × Share of FDI processing exports		0.250***	0.242***	0.189***	0.196***
		(0.044)	(0.048)	(0.049)	(0.051)
College × Ordinary exports ratio		0.246	0.199	0.271	0.222
		(0.190)	(0.229)	(0.166)	(0.210)
College × R&D ratio			-0.164		0.091
			(0.779)		(0.523)
College $\times K/Y$			0.030		0.023
			(0.023)		(0.015)
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)	(0.003)	(0.003)
State owned sector	0.195***	0.197***	0.196***	0.194***	0.194***
	(0.010)	(0.010)	(0.010)	(0.004)	(0.004)
First stage F-stat				> 157.66	> 144.33
Endogeneity test (p-value)				0.0913	0.1508
Constant, Province-year pair dummy	+	+	+	+	+
N	156,658	156,658	155,905	143,010	143,010
R^2	0.366	0.368	0.369	0.298	0.304

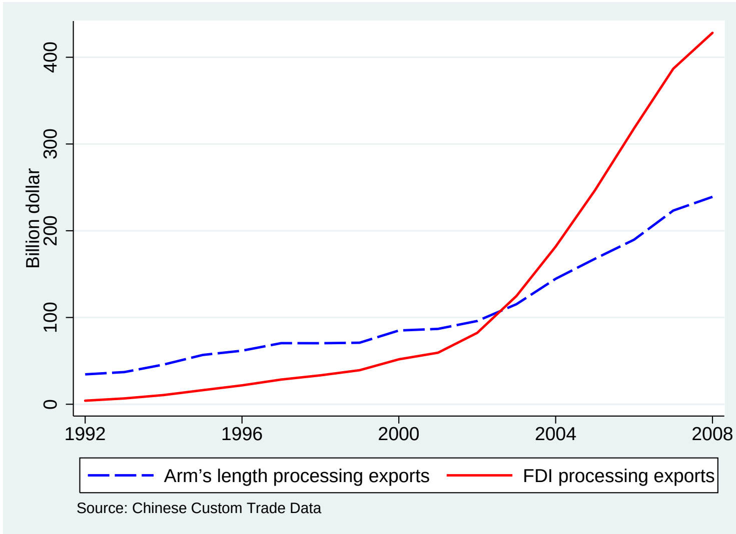
Note: the dependent variable is log annual wage income. Province-year cluster robust standard errors are in parentheses for OLS regression. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

[a] Regressions (4) and (5) are estimated by GMM, where we use the constructed processing exports ratio and the share of FDI processing exports as instruments, based on the sample of China's high-income trade partners (regression (4) in Table 3). The bootstrapped standard errors are in parentheses.

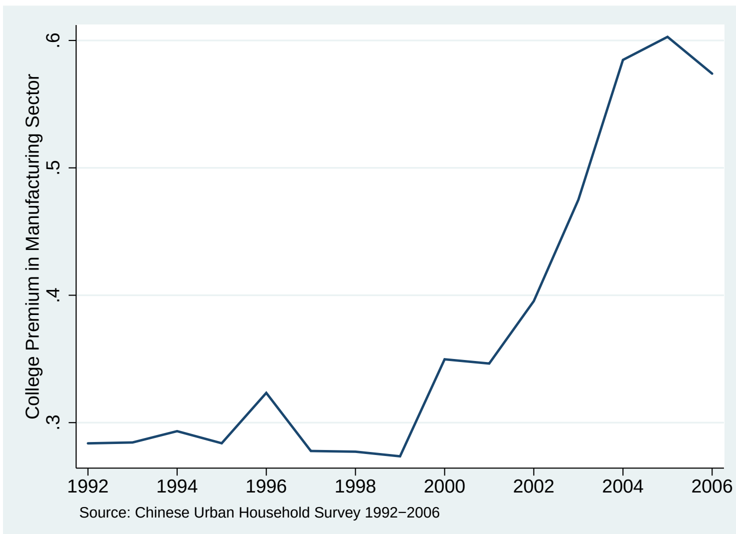
Table 6: Robustness Analysis on the College Premium

	Cultural Revolution Cohort only	Male only	Quality of College Education	All Trade Partners
Independent variables	(1)	(2)	(3)	(4)
College indicator	0.129***	0.181***	0.238***	0.221***
	(0.034)	(0.027)	(0.021)	(0.022)
College indicator interaction terms				
College $\times$ Processing exports ratio	0.505**	0.597***	0.894***	0.744***
	(0.229)	(0.186)	(0.177)	(0.146)
College $\times$ Share of FDI processing exports	0.226***	0.257***	0.188***	0.179***
	(0.070)	(0.065)	(0.054)	(0.052)
College $\times$ Ordinary exports ratio	0.065	-0.023	0.162	0.295
	(0.334)	(0.229)	(0.215)	(0.204)
College $\times$ R&D ratio	-1.085	0.594	0.066	-0.247
	(0.971)	(0.584)	(0.525)	(0.540)
College $\times K/Y$	0.056**	0.034*	0.016	0.023
	(0.025)	(0.018)	(0.015)	(0.015)
College $\times$ Teacher-student ratio			-0.006***	
			(0.002)	
Individual characteristics				
Experience	0.040***	0.052***	0.047***	0.047***
	(0.005)	(0.001)	(0.001)	(0.001)
Experience square	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Sex	-0.217***		-0.208***	-0.208***
	(0.005)		(0.003)	(0.004)
State owned sector	0.243***	0.152***	0.192***	0.195***
	(0.006)	(0.006)	(0.004)	(0.004)
First stage F-stat	> 168.23	> 154.33	> 137.10	> 141.37
Constant, Province-year pair dummy	+	+	+	+
N	51,775	79,086	137,316	143,010
R^2	0.297	0.287	0.301	0.303

Note: the dependent variable is log annual wage income. Regressions are estimated by GMM using the predicted processing exports ratio and the share of FDI processing exports as instruments. The bootstrapped standard errors are in parentheses. *, **, and *** indicate significance at the 10,5, and 1 percent levels.



(a) Ownership Structural Change in Processing Exports



(b) College Premium in the Manufacturing Sector

Note: FDI processing exports refers to processing exports by wholly foreign-owned firms, processing exports by joint ventures and domestic firms are called arm's length processing exports.

Figure 1: Processing Exports and College Premium in China

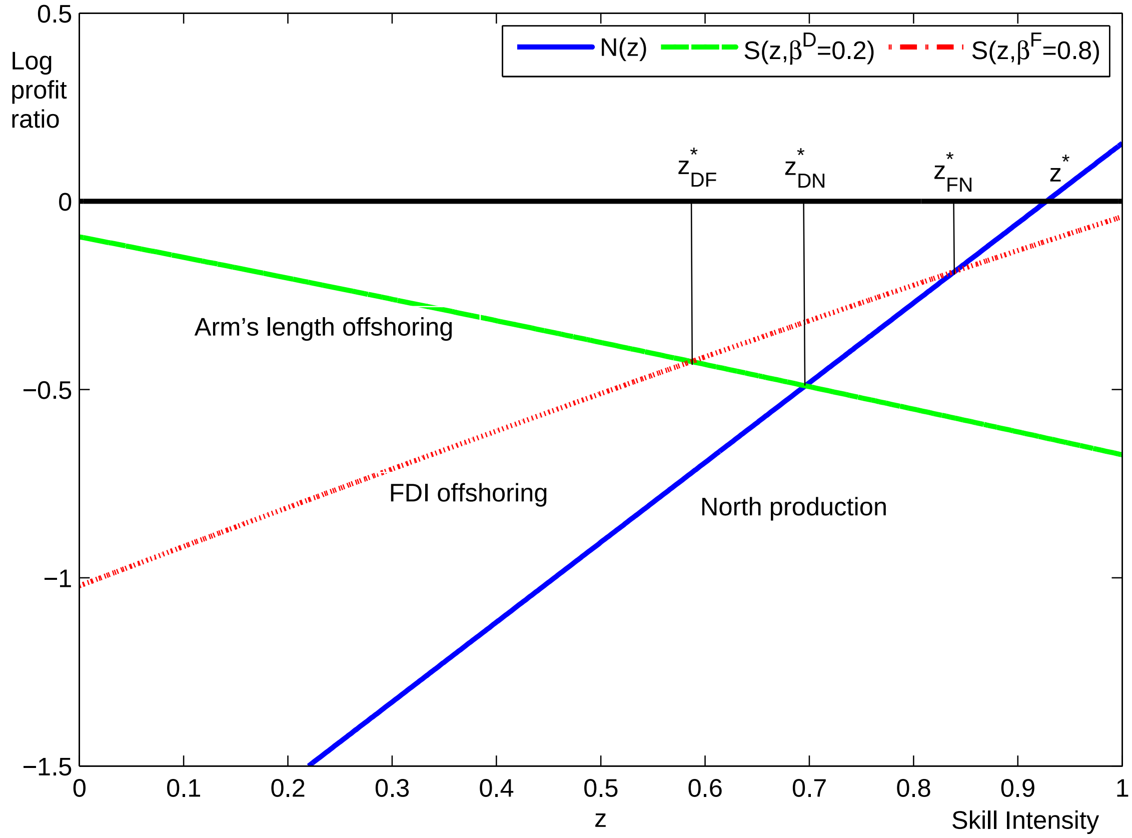


Figure 2: Offshoring, Optimal Ownership and Skill Intensity of Intermediate Goods

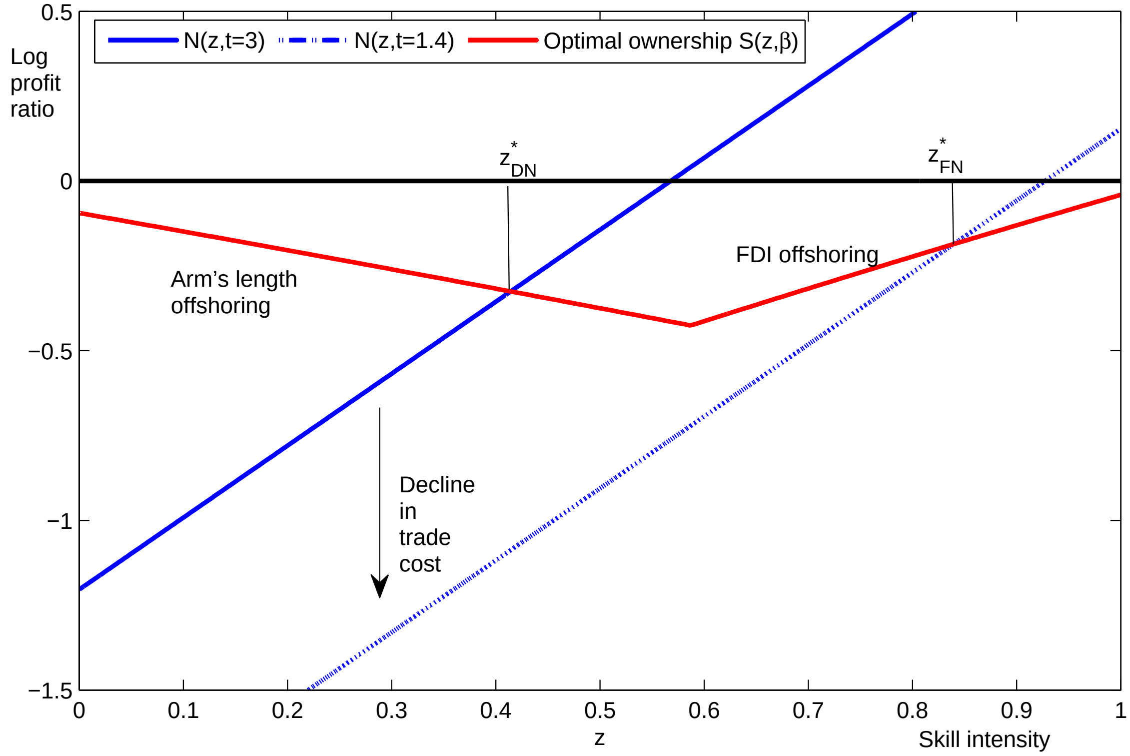


Figure 3: Trade liberalization, Offshoring and Skill Intensity of Intermediate Goods

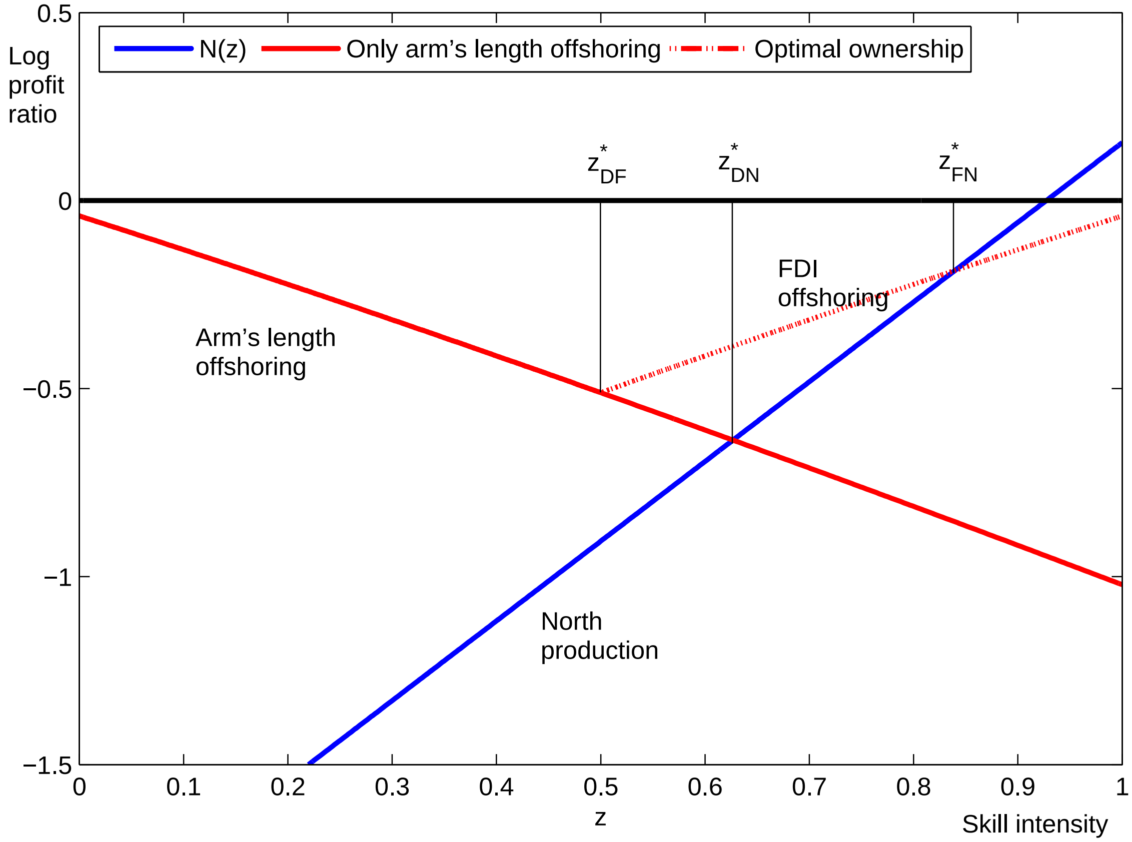
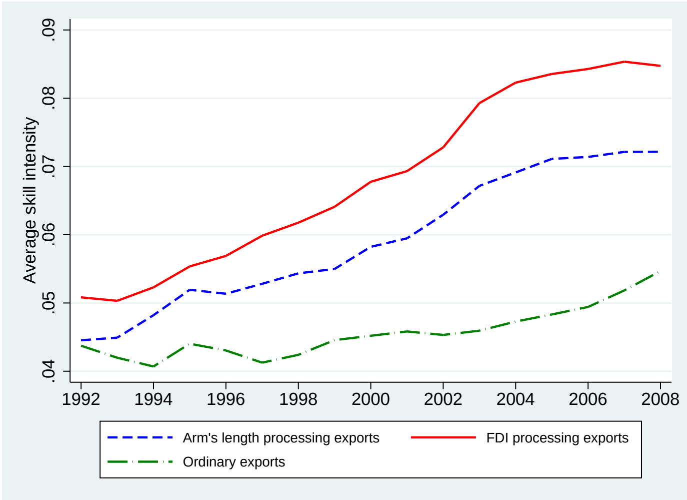


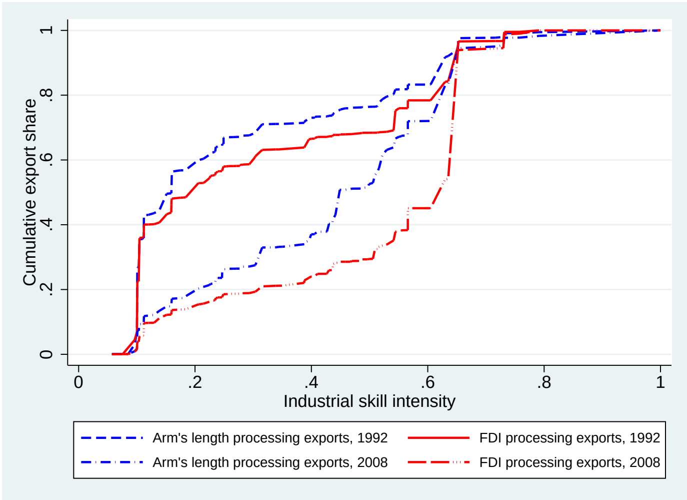
Figure 4: Ownership liberalization, Offshoring and Skill Intensity of Intermediate Goods

Figure 5: Skill Difference of Processing Exports

(a) Average Skill Intensity



(b) The Cumulative Distributions



Note: 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.

Appendices

A Properties of $S(z, \beta)$

In this appendix we show an important feature of $S(z, \beta)$ as follows:

Corollary 1 *$S(z, \beta)$ 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.*

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 these two inequalities are essential the same if we redefine $\hat{\beta} = 1 - \beta$ for the second one. Thus, we only need to prove the inequality for $\beta \in [1/2, 1]$. This 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 $g(\beta) = (1-\alpha\beta)^2$ is a convex function on the compact interval $[1/2, 1]$, 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 corner solution, we have $\beta^*(0)=0$ and $\beta^*(1)=1$, so our statement of $\beta^*(z)$ still holds.

B Proof for lemma 1

Lemma 1 *If the Northern innovators would offshore all intermediate goods to the South, the more skill-intensive intermediate goods are offshored through foreign affiliates ($z > z^*_{DF}$), and the less skill-intensive products are outsourced to southern owned firms ($z \leq z^*_{DF}$). Moreover, the cutoff z^*_{DF} is independent of offshoring cost.*

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

Corollary 2

(a) For $\beta = 1/2$, $\frac{\partial S(z,\beta)}{\partial z} = 0$ and $S(z,1/2) < 0$.

(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.

(c) For $\beta < 1/2$, $\frac{\partial S(z,\beta)}{\partial z} < 0$, $S(z=1,\beta<1/2) < S(z=1,1/2) = S(z=0,1/2) < S(z=0,\beta<1/2) \leqslant 0$. Since $\beta^D < 1/2$, this implies that the log profit ratio of Southern-owned firms decreases in z.

(d) Moreover, there exists a unique cutoff $z^*_{DF} \in (0,1)$, such that $S(z^*_{DF},\beta^D) = S(z^*_{DF},\beta^F)$, and $S(z,\beta^D) > S(z,\beta^F)$ if $z < z^*_{DF}$, and $S(z,\beta^D) < S(z,\beta^F)$ if $z > z^*_{DF}$.

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), because $S(z,\beta)$ 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, $S(z,\beta)$ increases in z for $\beta > 1/2$, and decreases for $\beta < 1/2$. Moreover, since $f(x) = \ln x + \frac{1-\alpha}{\alpha}[\ln(1-\alpha x) - ln(1-\alpha)]$ increases in x if $x \in (0,1)$, then $f(x) \leq 0$ 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. Based on these properties, it is easy to show that corollary (b) and (c) hold. Because $S(z,\beta^F)$ increases in z and $S(z,\beta^D)$ decreases in z, and $S(z=0,\beta^F) < S(z=0,\beta^D)$ and $S(z=1,\beta^F) > S(z=1,\beta^D)$, then there two curves only has one crossing point denoted as $z^*_{DF} \in (0,1)$. Thus, corollary (d) also holds. Moreover, as $S(z,\beta)$ does not depend on the offshoring cost, thus the cutoff z^*_{DF} also does not change as the offshoring cost varies.

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 1, we can show the following corollary.

Corollary 3

(1) If Assumption 1 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 offshoring 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 1(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 $r(z,\beta) \leq r(0,\beta) = \ln(\frac{t}{(1-\beta)\omega_l}(\frac{1-\alpha}{1-\alpha(1-\beta)})^{\frac{1-\alpha}{\alpha}})$. 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 1(2). Thus $B(z,\beta,t)$ is an increasing and continuous function of z, and $B(1,\beta,t) > 0$, $\underset{z\to 0}{lim} B(\beta,z,t) < 0$. Clearly there must be a unique cutoff $z^*(t,\beta) \in (0,1)$ such that $B(z^*(t,\beta),\beta,t) = 0$. 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 $\beta^D < \beta^F$, there exists at most two different cutoffs $z^*_{ON}(t) \in (0,1)$, for $O = F, D$. The above lemma implies that the most skill-intensive intermediate goods are produced in the North, i.e. for any $z > \max\{z^*_{DN}(t), z^*_{FN}(t)\}$, and $\pi(z) = \pi^N(z)$. Moreover, it is easy to show that the order of $z^*_{FN}(t), z^*_{DN}(t)$ must be one of the four cases: (1) $z^*_{FN}(t) > z^*_{DN}(t)$; (2) $z^*_{FN}(t) = z^*_{DN}(t)$; (3) $z^*_{DN}(t) > z^*_{FN}(t)$. In the first case, three production modes coexist; in the second and third case, the North foreign ownership ($O = F$) will not be optimal for any product z. Moreover, the first case also implies $z^*_{FN}(t) > z^*_{DF}$. Because if $z^*_{FN}(t) \leq z^*_{DF}$, then $z^*_{DN}(t) \geq z^*_{FN}(t)$ which is contradictory to the inequality in the first case. Thus, in the case of three 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 1, among these products offshored to the South, the more skill-intensive are through FDI offshoring ($z^*_{FN}(t) > z > z^*_{DF}$), the less skill-intensive are through arm's length offshoring ($z \leq z^*_{DF}$). Thus, there exists a unique set $(z^*_{FN}(t), z^*_{DF})$, which indicates the boundary of four production modes. Moreover, as the offshoring cost t decreases, $z^*_{FN}(t)$ increases.

D Proof for Proposition 2

The optimal revenue can be derived from firm's optimization problem when the Northern innovator chooses to offshore her production.

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

If two types of offshoring coexist, we must have $z^*_{DF} < z^*_{FN}(t)$. Thus, the revenue share of foreign firms in process export is given by

$$\Upsilon^F(t) = \frac{\int\limits_{z^*_{JF}}^{z^*_{FN}(t)} R(z,\beta^F)dF(z)}{\int\limits_{0}^{z^*_{DF}} R(z,\beta^D)dF(z) + \int\limits_{z^*_{DF}}^{z^*_{FN}(t)} R(z,\beta^F)dF(z)} = \frac{\int\limits_{z^*_{JF}}^{z^*_{FN}(t)} \tilde{R}(z,\beta^F)dF(z)}{\int\limits_{0}^{z^*_{DF}} \tilde{R}(z,\beta^D)dF(z) + \int\limits_{z^*_{DF}}^{z^*_{FN}(t)} \tilde{R}(z,\beta^F)dF(z)}$$

where $F(z)$ is the distribution of intermediate goods z, and $\widetilde{R}(z,\beta) = R(z,\beta)/(\frac{1}{t})^{\alpha/(1-\alpha)}$. Now the offshoring cost t affects the revenue share of foreign firms only through the extensive margin, i.e. cutoff $z^*_{FN}(t)$. 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 offshoring cost t decreases. Thus a reduction in the offshoring cost increases the FDI offshoring.

E Proof of Proposition 4

(1). The proof is straightforward for the case where only arm's length offshoring is possible. Below we provide the proof when two types of offshoring coexist. Let $\overline{z}$ denote the cutoff between North-South production.

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

due to the fact that $h(\overline{z},\beta^F)/l(\overline{z},\beta^F) \geq h(\overline{z},\beta^O)/l(\overline{z},\beta^O) > h(z,\beta^O)/l(z,\beta^O)$ for $z < \overline{z}$, and for $O = D, F$. This increasing skill demand due to the extensive margin growth is similar to the mechanism of Feenstra and Hanson (1996a), but note that the ownership structure amplifies the impact of the extensive margin of export on the skill demand. Because the term in bracket of numerator can be decomposed into two parts: $[h(\overline{z},\beta^F)/l(\overline{z},\beta^F) - h(z,\beta^O)/l(z,\beta^O)] = [\frac{h(\overline{z},\beta^F)}{l(\overline{z},\beta^F)} - \frac{h(\overline{z},\beta^O)}{l(\overline{z},\beta^O)}] + [\frac{h(\overline{z},\beta^O)}{l(\overline{z},\beta^O)} - \frac{h(z,\beta^O)}{l(z,\beta^O)}]$. Both terms in brackets are non-negative, and the first term indicates the amplification effect of ownership structure, while the second term captures the pure effect of extensive margin growth on skill demand. (2). Define $\Omega_1 = [0, z^*_{DF}]$, $\Omega_2 = [z^*_{DF}, z^*_{DN}]$, and $\Omega_3 = [z^*_{DN}, z^*_{FN}]$, then

the aggregate skill demands before and after ownership liberalization are given as follows:

$$D_0 = \frac{\int_{\Omega_{1,2}} h(z,\beta^D)dz}{\int_{\Omega_{1,2}} l(z,\beta^D)dz}$$

$$D_1 = \frac{\int_{\Omega_1} h(z,\beta^D)dz + \int_{\Omega_{2,3}} h(z,\beta^F)dz}{\int_{\Omega_1} l(z,\beta^D)dz + \int_{\Omega_{2,3}} l(z,\beta^F)dz}$$

We can show

$$
\begin{aligned}
D_1 - D_0 \sim & \left(\int_{\Omega_1} h(z,\beta^D)dz + \int_{\Omega_{2,3}} h(z,\beta^F)dz\right)\int_{\Omega_{1,2}} l(z,\beta^D)dz \\
& - \int_{\Omega_{1,2}} h(z,\beta^D)dz \left(\int_{\Omega_1} l(z,\beta^D)dz + \int_{\Omega_{2,3}} l(z,\beta^F)dz\right) \\
& = \left[\int_{\Omega_1} l(z,\beta^D)dz\left(\int_{\Omega_2} h(z,\beta^F) - h(z,\beta^D)dz\right) - \int_{\Omega_1} h(z,\beta^D)dz\left(\int_{\Omega_2} l(z,\beta^F) - l(z,\beta^D)dz\right)\right] \\
& + \left[\int_{\Omega_3} h(z,\beta^F)dz\int_{\Omega_{1,2}} l(z,\beta^D)dz - \int_{\Omega_{1,2}} h(z,\beta^D)dz\int_{\Omega_3} l(z,\beta^F)dz\right] \\
& + \left[\int_{\Omega_2} h(z,\beta^F)dz\int_{\Omega_2} l(z,\beta^D)dz - \int_{\Omega_2} h(z,\beta^D)dz\int_{\Omega_2} l(z,\beta^F)dz\right].
\end{aligned}
$$

Next we show each term in three brackets are all non-negative. The first one is

$$
\begin{aligned}
& \int_{\Omega_1} l(y,\beta^D)dy\left(\int_{\Omega_2} h(z,\beta^F) - h(z,\beta^D)dz\right) - \int_{\Omega_1} h(y,\beta^D)dy\left(\int_{\Omega_2} l(z,\beta^F) - l(z,\beta^D)dz\right) \\
& = \int_{y\in\Omega_1}\int_{z\in\Omega_2} l(y,\beta^D)\left[h(z,\beta^F) - h(z,\beta^D)\right] - h(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right]dzdy \\
& = \int_{y\in\Omega_1}\int_{z\in\Omega_2} h(z,\beta^D)l(y,\beta^D)\left[h(z,\beta^F)/h(z,\beta^D) - 1\right] - h(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right]dzdy \\
& > \int_{y\in\Omega_1}\int_{z\in\Omega_2} h(z,\beta^D)l(y,\beta^D)\left[l(z,\beta^F)/l(z,\beta^D) - 1\right] - h(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right]dzdy \\
& = \int_{y\in\Omega_1}\int_{z\in\Omega_2} \frac{h(z,\beta^D)}{l(z,\beta^D)}l(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right] - h(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right]dzdy \\
& \geqslant \int_{y\in\Omega_1}\int_{z\in\Omega_2} \frac{h(y,\beta^D)}{l(y,\beta^D)}l(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right] - h(y,\beta^D)\left[l(z,\beta^F) - l(z,\beta^D)\right]dzdy \\
& = 0
\end{aligned}
$$

The first inequality is because $h(z,\beta^F)/l(z,\beta^F) > h(z,\beta^D)/l(z,\beta^D)$, and the second is because $h(z,\beta^D)/l(z,\beta^D) \geqslant h(y,\beta^D)/l(y,\beta^D)$, for $z \geqslant y$. Also the second bracket is

$$
\begin{aligned}
& \int_{\Omega_3} h(z,\beta^F)dz\int_{\Omega_{1,2}} l(y,\beta^D)dy - \int_{\Omega_{1,2}} h(y,\beta^D)dz\int_{\Omega_3} l(z,\beta^F)dy \\
& = \int_{\Omega_3}\int_{\Omega_{1,2}} h(z,\beta^F)l(y,\beta^D) - h(y,\beta^D)l(z,\beta^F)dydz \\
& = \int_{\Omega_3}\int_{\Omega_{1,2}} \left[\frac{h(z,\beta^F)}{l(z,\beta^F)} - \frac{h(y,\beta^D)}{l(y,\beta^D)}\right] l(z,\beta^F)l(y,\beta^D)dydz > 0
\end{aligned}
$$

Next we show that the third bracket is non-negative if $\alpha \leq 1/2$.It is sufficient to show $h(z, \beta^F) \geqslant h(z, \beta^D)$, and $l(z, \beta^D) \geqslant l(z, \beta^F)$ for $z \in [0, 1]$.

$$\frac{h(z,\beta^F)}{h(z,\beta^D)} = \frac{\alpha\beta^F zR(z,\beta^F)/q}{\alpha\beta^D zR(z,\beta^D)/q} = \frac{\beta^F[(\frac{\beta^F}{1-\beta^F})^z]^{\alpha/(1-\alpha)}(1-\beta^F)^{\alpha/(1-\alpha)}}{\beta^D[(\frac{\beta^D}{1-\beta^D})^z]^{\alpha/(1-\alpha)}(1-\beta^D)^{\alpha/(1-\alpha)}}$$

Using the fact that $\beta^F + \beta^D = 1$, and $\beta^F > 1/2$, we can show $\frac{h(z,\beta^F)}{h(z,\beta^D)} = (\frac{\beta^F}{1-\beta^F})^{(1-2\alpha+2\alpha z)/(1-\alpha)} \geq 1$ for $z \in [0, 1]$ if $\alpha \leq 1/2$. Similarly we can show that this condition is sufficient for $l(z, \beta^D) \geqslant l(z, \beta^F)$, i.e.,

$$\begin{aligned}\frac{l(z,\beta^F)}{l(z,\beta^D)} &= \frac{\alpha(1-\beta^F)(1-z)R(z,\beta^F)/w}{\alpha(1-\beta^D)(1-z)R(z,\beta^D)/w} \\ &= \frac{(1-\beta^F)[(\beta^F)^z(1-\beta^F)^{(1-z)}]^{\alpha/(1-\alpha)}}{(1-\beta^D)[(\beta^D)^z(1-\beta^D)^{(1-z)}]^{\alpha/(1-\alpha)}} \\ &= (\frac{1-\beta^F}{\beta^F})^{(1-2\alpha z)/(1-\alpha)} \leq 1 \text{ for } z \in [0, 1].\end{aligned}$$

Thus, we have $D_1 > D_0$, i.e., ownership liberalization increases the aggregate relative demand for skilled workers. Note the second bracket implies that $\int_{\Omega_3} h(z, \beta^F)dz / \int_{\Omega_3} l(z, \beta^F)dz > \int_{\Omega_{1,2}} h(z, \beta^D)dz / \int_{\Omega_{1,2}} l(z, \beta^D)dz$, indicating that the the aggregate relative skill demand due to newly offshored goods $z \in \Omega_3$ is higher than previous offshored goods. Moreover, the term in third bracket also implies that $\int_{\Omega_2} h(z, \beta^F)dz / \int_{\Omega_2} l(z, \beta^F)dz \geq \int_{\Omega_2} h(z, \beta^D)dz / \int_{\Omega_2} l(z, \beta^D)dz$, therefore the relative skill demand also increases due to the ownership reconstruction for the goods $z \in \Omega_2$.

F Empirical Appendix

F.1 Augmented Mincer Wage Regression

The following graphs plot the actual processing exports ratio and the share of FDI processing exports against their predicted values, and clearly show significant correlations between the actual and predicted values.

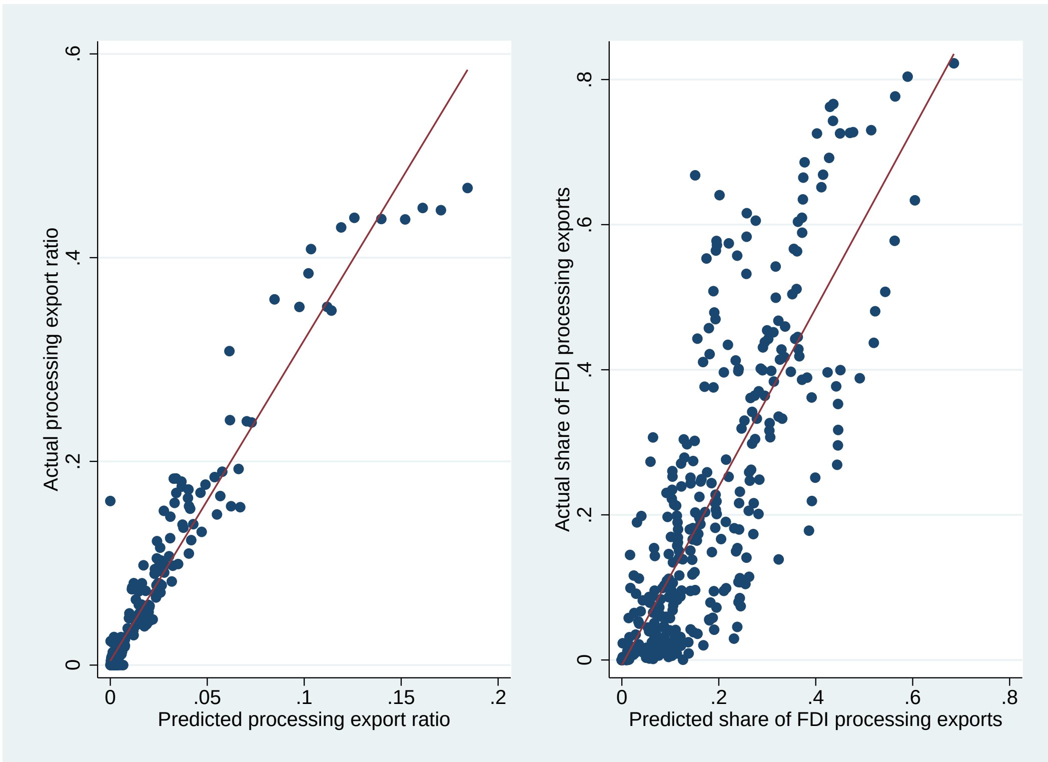


Figure F.1: Scatter Plot for First Stage Regression

Table F.1: Determinants of Rate of Return to Education in Urban China

	OLS			IV[a]	
Independent variables	(1)	(2)	(3)	(4)	(5)
Schooling years	0.063***	0.046***	0.038***	0.049***	0.039***
	(0.002)	(0.002)	(0.005)	(0.001)	(0.006)
Schooling years indicator interaction terms					
Schooling years × Processing exports ratio		0.055**	0.061**	0.069***	0.075***
		(0.028)	(0.028)	(0.027)	(0.026)
Schooling years × Share of FDI processing exports		0.059***	0.061***	0.054***	0.059***
		(0.008)	(0.008)	(0.009)	(0.009)
Schooling years × Ordinary exports ratio		0.013	-0.024	-0.004	-0.067
		(0.035)	(0.050)	(0.021)	(0.027)
Schooling years × R&D ratio			0.189		0.381***
			(0.195)		(0.085)
Schooling years $\times K/Y$			0.006		0.007*
			(0.004)		(0.002)
Individual characteristics					
Experience	0.048***	0.048***	0.048***	0.046***	0.046***
	(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	-0.195***	-0.194***	-0.194***	-0.200***	-0.200***
	(0.006)	(0.006)	(0.006)	(0.003)	(0.003)
State owned sector	0.176***	0.178***	0.178***	0.176***	0.176***
	(0.010)	(0.010)	(0.010)	(0.004)	(0.004)
First stage F-stat				> 189.70	> 173.90
Constant, Province-year pair dummy	+	+	+	+	+
N	156,658	156,658	155,905	143,010	143,010
R^2	0.373	0.376	0.377	0.307	0.320

Note: the dependent variable is log annual wage income. Province-year cluster robust standard errors are in parentheses for OLS regression. *, **, 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 processing exports ratio and the share of FDI processing exports as instruments, based on the sample of China's high-income trade partners. The bootstrapped standard errors are in parentheses.

F.2 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.3 Provincial variables

Table F.2: Variable discription

Variable	Definition	Source
Collshr	The Share of population aged above 5 with college degrees	Annual Population Survey, published in China Population Statistics Yearbook, 1993-2009.
R&D ratio	R&D expenditure/nominal GDP	China Statistical Yearbook on Science and Technology, 1993-2009.
K/Y	Capital stock/real GDP, in 1978 price	Capital stock is provided by Qian et al. (2007). Real GDP is computed from China Compendium of Statistics 1949-2008.
Court efficiency	0.5-courtcost	Word Bank Doing Business Survey
Infrastructure	Log(the # of km of highways and railways per square km)	China Compendium of Statistics 1949-2008
National policy zones	The number of national policy zones	China Development Zone Review Announcement Catalogue, NDRC, 2007.