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ABSTRACT

Offshoring and Wage Inequality: Theory and Evidence from China*

We present a global production sharing model that integrates the organizational choices of offshoring into the determination of relative wages in developing countries. The model shows that offshoring through foreign direct investment contributes more prominently than arm's length outsourcing to the demand for skill in the South, thereby increasing the relative wage of skilled workers. We incorporate these theoretical results into an augmented Mincer earnings function and test the model based on a natural experiment in which China lifted its restrictions on foreign ownership for multinational companies upon its accession to the World Trade Organization in 2001. Empirical findings based on detailed Urban Household Surveys and trade data from Chinese customs provide support to our proposed theory, thus shedding light on the changes in firm ownership structure, the skill upgrading in exports, and the evolution of wage inequality from 1992 to 2008 in China's manufacturing sector.

JEL Classification: F16, J31, D23

Keywords: offshoring, ownership structure, processing trade, wage inequality, China

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1 Introduction

In recent decades, trade in intermediate inputs through FDI and arm's length offshoring has gained prominence in the global economy. Approximately two-thirds of the world trade consist of transactions in intermediate inputs, and about half of such transactions is conducted within the boundaries of multinational companies (MNCs).[1] The dramatic rise of offshoring has stimulated many researchers to investigate the microeconomic structure and the effect of global sourcing on wage inequality. Seminal papers, such as those of Antràs (2003) and Antràs and Helpman (2004), have investigated firms' offshoring decision and organizational choices between FDI and outsourcing. A key insight is that the ownership structure of offshoring greatly depends on the factor intensity (i.e., headquarter service or skill content) of offshored production. Meanwhile, the pioneering work of Feenstra and Hanson (1996) and subsequent studies have examined the effect of aggregate offshoring on the skill premia,[2] without distinguishing the two types of offshoring. Surprisingly, previous studies have not yet explored systematically the effects of microeconomic structure of offshoring on wage inequality in developing countries despite the comparable importance of FDI and arm's length offshoring in the global economy.

This paper develops a framework that integrates the ownership structure of offshoring into the determination of relative wages in developing countries and draws empirical evidence from China. China provides a unique laboratory to test our model for two reasons. First, China emerged as "the world's factory" after its accession to the World Trade Organization (WTO) in 2001 while becoming "the magnet for FDI" among developing countries. Foreign firms contributed approximately one-third to the gross industrial out-

[1]See Johnson and Noguera (2012). Corroborative estimates from UNCTAD (1999, p. 232) show that one-third of the world trade comprised intermediate inputs exchanged within firms.

[2]For instance, Feenstra and Hanson (1997, 1999) and Hsieh and Woo (2005) find empirical evidence that offshoring increased the skill premia in the United States, Mexico, and Hong Kong from 1980 to 2000. See Goldberg and Pavcnik (2007) and Hummels et al. (2016) for a literature review.

put of China.[3] Second, China provides an intriguing natural experiment of changing policy regimes in regulating foreign investment. Until the late 1990s, the Chinese government had imposed restrictions on wholly foreign-owned companies yet encouraged joint ventures and arm's length offshoring. However, upon its accession to the WTO, China began to relax its ownership restrictions on MNCs in the manufacturing sector. Since then, wholly foreign-owned affiliates have grown extensively and have become dominant forces in foreign investment and processing trade. Such liberalization of MNC ownership, which is induced largely by external factors, presents a unique opportunity for investigating the effects of the ownership structural changes of offshoring on skill upgrading in exports and skill premium in China.

Figure 1 presents two empirical observations that motivate the current study. Figure 1(a) shows that the composition of FDI and arm's length offshoring in China has changed dramatically over time.[4] Although both types of processing exports grew at an approximately equal rate prior to 2001, the growth of FDI processing exports outpaced that of outsourcing since China's accession to the WTO. Closely correlated to this timing, Figure 1(b) illustrates that the college wage premium in the Chinese manufacturing sector remained flat before 2001 but increased dramatically thereafter. The average earnings gap between workers with and without college education was approximately 30% throughout the 1990s, but the skill premium increased to 55% by 2006. These empirical observations raise important questions that this papers seeks to answer. What policies and institutions can affect the composition of FDI and arm's length offshoring in the South? How

[3]According to statistical yearbooks published by the National Bureau of Statistics (NBS) of China, foreign firms accounted for 32% and 28% of gross industrial output and value added in 2006, respectively, and approximately half of such came from wholly foreign-owned firms. NBS stopped reporting these figures after 2006, but the contribution of foreign firms has grown in the past decade.

[4]FDI offshoring is measured as the processing exports of wholly foreign-owned enterprises, whereas arm's length offshoring is defined as the processing exports of joint ventures and Chinese domestic firms. We use processing exports as a measure of offshoring because such activity 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-export products to foreign markets. In other words, processing exports are offshored production from foreign countries (Feenstra and Hanson, 2005). Processing exports play a major role in international trade in China, accounting for an average of 56% of the total exports of the country from 1992 to 2008.

can different types of offshoring influence the skill demand in developing countries and therefore affect the returns to skill?

We address these questions by developing a two-country, two-factor model of offshoring and wage inequality in developing countries. By introducing the property rights theory (Grossman and Hart, 1986; Antràs, 2005) into the offshoring framework (Feenstra and Hanson, 1996), our model not only disentangles the role of comparative advantage and contractual frictions in shaping the pattern of global sourcing, but also illustrates two different channels through which offshoring can affect the skill demand in the South. The first channel is the Feenstra-Hanson mechanism through which the relatively more skill-intensive products offshored from the North increases the skill demand in the South. The second is the ownership mechanism (e.g., Antràs, 2003; Antràs and Helpman, 2004; hereafter referred to as the Antràs mechanism) in which multinationals offshore more skill-intensive production to its foreign affiliates and outsource low-skill activities because of incomplete contracts in the South. Accordingly, FDI offshoring contributes more than outsourcing to the skill demand in the South. Based on the model, we analyze two sets of institutional and policy reforms, namely, ownership liberalization of the MNCs and reduction in offshoring cost in host countries, that can attract FDI offshoring, thus increasing the demand for and returns to skill in the South. The ownership mechanism forges a novel and potentially important linkage between offshoring and skill premium because of the prevalence of ownership restrictions and high offshoring cost in many developing countries (Kalinova et al., 2010; UNCTAD, 2006). To test our model predictions, we incorporate the theoretical results into an augmented Mincer wage regression to examine the determinants of skill premium with an implementable empirical specification.

In the empirical analysis, we processed and combined three comprehensive datasets that cover the years from 1992 to 2008, namely, (a) the national sample of Chinese Urban Household Surveys (CUHS), which contains rich information on earnings and demographic characteristics of households and individuals, (b) the Chinese customs trade data that contain detailed descriptions of by-product exports and firm characteristics, and (c) aggregate variables that capture the institutional and economic conditions of labor markets at the province level. We also constructed two indicator variables for "encouragement" and "restriction" policies by industry based on a series of government deregulation policies that liberalize the ownership structure of MNCs. Moreover, we measured local offshoring costs by using information on the transportation infrastructure and accumulative numbers of national policy zones.

Under a two-stage identification strategy, we find that FDI offshoring is more skill intensive than arm's length offshoring, thereby confirming a key result of the model. Moreover, the ownership liberalization of MNCs and the reduction in offshoring costs generate an asymmetric effect by increasing FDI offshoring more than arm's length offshoring. In the second stage, we estimate the augmented Mincer regression based on rich spatial and time variations in trade exposure because the CUHS and trade data cover 30 Chinese provinces for 14 and 16 years respectively. The regression estimates indicate that aggregate offshoring (the Feenstra-Hanson mechanism) and the share of FDI offshoring (the Antràs mechanism) are both important determinants of college wage premium in China. These findings are robust to alternative control variables and other sensitivity checks, including the endogeneity of worker ability and the selection of locations by multinationals. The FDI offshoring triggered by the ownership liberalization of MNCs and the reduction in offshoring cost can quantitatively explain approximately 34% of the increase in college wage premium in the Chinese manufacturing sector between 2000 and 2006. The effect of FDI offshoring far exceeds that of skill-biased technological changes and capital-skill complementarity.

This paper is closely related to the literature on the organization of multinationals in global production.[5] Previous studies mainly focus on the joint determination of offshoring and the organizational structure of firms, without exploring the consequences

[5]Other representative studies, which are not yet cited, include Grossman and Helpman (2005) and Costinot et al. (2011).

of MNC decisions on factor prices. By introducing skilled and unskilled labor into the framework, we forge a link between the behavior of multinationals and skill demand in developing countries. We also investigate the institutional foundation of an MNC's organizational choice, namely, the regulations on foreign ownership and the government policies that affect offshoring costs, which complement the emphasis on incomplete contracts. To the best of our knowledge, this study is the first to identify the significant effect of the organizational structure of offshoring on wage inequality in a large developing country. Therefore, this paper contributes to the broader literature on globalization and income distribution.

The influential works of Feenstra and Hanson (1996) and subsequent studies analyze the effect of aggregate offshoring on wage inequality with an emphasis on the North (e.g., Grossman and Rossi-Hansberg, 2008; Hummels et al., 2014). This study departs from the literature by distinguishing FDI from arm's length offshoring. The differential effects of two types of offshoring on the demand for skill highlight the importance of policy reforms in developing countries because removing restrictions on foreign ownership and lowering offshoring costs can induce MNCs to transfer skill-intensive production to the South. Goldberg and Pavcnik (2007) point toward the limited number of studies on the effect of globalization on income distribution in China[6], despite the fact that the "China trade shock" has attracted significant attention from researchers since the work of Autor et al. (2013). Therefore, this paper fills a void in the literature by shedding light on the evolving income distribution in China as well as the effect of globalization on inequality because of China's increasing significance in the global economy.

The rest of this paper is organized as follows. Section 2 presents the theoretical framework, derives testable hypotheses in the context of an augmented Mincer equation, and formulates an identification strategy. Section 3 describes the globalization process in China, the natural experiment of policy changes, and the data for empirical analysis. Sec-

[6]A notable exception is Han et al. (2012), who examine how the rising trade of final goods affects the income inequality in six provinces in China.

tion 4 reports the empirical findings. Section 5 presents the concluding remarks with discussions on policy reforms.

2 The Model

In this section, we develop a 2-country $\times$ 2-factor model to study the joint decisions of MNCs on offshoring and ownership structure, with an emphasis on the contractual frictions and institutional environment of the host country. Our model forges a new linkage between the organizational choice of MNCs and the demand for skill in the South. We apply this model to investigate the consequences of two policy reforms, namely, ownership liberalization of MNCs and reductions in offshoring cost on the returns to skill in developing countries.

2.1 Setup

The world consists of two countries, the North and the South. There are two types of labor, high- and low-skilled workers, who are immobile across the border, which we denote by h and l, respectively. The wages of high- and low-skilled workers in country c are denoted by q^c and w^c, 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 costlessly over a continuum of differentiated products indexed by $z \in [0, 1]$ with a constant-elasticity-of-substitution form in a specific 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 the aggregate demand for the differentiated goods under the assumption that these goods are freely shipped without costs, while 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 a more intensive use of high technology in production. Our model builds on Antràs (2005), but has several significant differences. First, Antràs (2005) only considers one type of labor, while we specify two types of labor to explore the impact of offshoring on the demand for skill. For simplicity, we assume that one unit of high-tech (low-tech) input requires one unit of high-skilled labor h (low-skilled l).[7] Second, similar to Feenstra and Hanson (1996, 1997), we assume that the production of each intermediate good $y(z)$ is not fragmentable, that is the two inputs are produced at the same location for manufacturing the good z.[8] While Antràs analyzes the processes of innovation and production in the context of the product cycle, we focus on the effects of offshoring on the relative wages in the South.

For any intermediate good z, only the Northern innovator has the technology (blueprint) to produce the high-tech input, but this innovator must find a low-tech input supplier in the North or South. The investments by the two parties are assumed to be relation specific. The supplier also pays the innovator a lump-sum transfer T, which will make the supplier break even. If the Northern innovator sources the low-tech inputs from domestic suppliers, then the contract is assumed to be complete. However, if this innovator offshores the inputs, then she faces incomplete contracts because of the poor legal environment in the South. Moreover, the Northern innovator can choose the ownership of her joint production. She can either set up a foreign affiliate ($O = F$), or outsource to the Southern suppliers ($O = D$). Apart from the incomplete contract, offshoring requires an additional effort in managing business overseas (Grossman and Rossi-Hansberg, 2008). We assume that this offshoring cost is proportional to the output of good z, which means

[7] This assumption can be relaxed to accommodate differences in labor productivity across countries.

[8] In Feenstra and Hanson (1996, 1997), MNCs can offshore the production of intermediate goods, but such production is not fragmentable. By contrast, Grossman and Rossi-Hansberg (2008) and Antràs (2005) assume a fragmentable production, that is, the North can offshore high or low input production to the South separately. The reality is likely in between these two approaches.

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. Given that the contract is complete, the firm chooses low-skilled workers l^N and high-skilled worker h^N 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 following profit:

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

If the Northern innovator opts to offshore, then the innovator and the Southern supplier will bargain over the surplus from their relation-specific investment after production due to incomplete contracts. Thus, the supplier sets l^S to maximize $(1-\beta)R(z) - w^S l^S$, and the innovator sets h^S to maximize $\beta R(z) - q^S h^S$, 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 firm finalizes the contract by setting T so as to make the low-tech supplier break even and to 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 $z \in [0,1]$.

The Northern innovator's revenue share β is determined by the ownership structure. If the innovator owns the firm ($O = F$), then she can fire the low-tech supplier who will be left with nothing in case they do not achieve agreement in their bargaining. However, the innovator can still obtain δ fraction of the output, where $0 < \delta < 1$, thereby generating a 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 contrast, if the Southern supplier owns the firm ($O = D$), then the innovator's share in revenue is

$\beta^D = \frac{1}{2}(1-\delta^\alpha)$. Clearly, we have $0 < \beta^D < 1/2 < \beta^F < 1$.[9]

2.2 Sourcing Location and Ownership Choice

The Northern innovator's ex ante profit is given by $\pi(z) = \max\{\pi^N(z), \pi^S(z,\beta^F), \pi^S(z,\beta^D)\}$. Compared with the North, the South has abundant cheap low-skilled labor yet suffers from the iceberg offshoring cost and an 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 benchmark where the South also has complete contracts. The corresponding profit for this benchmark is $\pi^S(z) = (1-\alpha)\lambda[\alpha(1/q^s)^z(1/w^s)^{(1-z)}]^{\alpha/(1-\alpha)}(1/t)^{\alpha/(1-\alpha)}$.

To begin with, we consider a hypothetical case in which both the North and the South have complete contracts. Let $N(z)$ denote the corresponding "log profit ratio" of the Northern production relative to the Southern production:

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

where $\omega_h = q^N/q^S$ and $\omega_l = w^N/w^S$. Given that the North has an abundant supply of high-skilled labor, we assume that $\omega_h < \omega_l$. To rule out the extreme case in which all products are produced in one location, we assume that $\omega_h < t < \omega_l$. In this case, $N(z)$ increases in z, and there exists an unique interior solution $z^*(t) \in (0,1)$ such that $N(z^*(t)) = 0$. Therefore, 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 generates the same pattern in Feenstra and Hanson (1996), who found that comparative advantage plays a crucial role in the allocation of global production sharing. Moreover, the offshoring cost dampens the comparative advantage of the South. In this case, a reduction in offshoring costs can help attract more

[9]The previous version of the paper shows that the qualitative results of the model still hold in the presence of a joint venture with $\beta = 1/2$, indicating that both parties have the veto power.

skill-intensive products to relocate to the South.

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

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

where $\beta \in (0,1)$. This normalization procedure cancels out most of the common factors in the profit function $\pi^S(z,\beta)$, such as the demand shifter λ, factor prices, and offshoring costs, but highlights the key factors of ownership choice. The ownership choice in the South is independent of factor prices, offshoring costs, and the demand shifter, instead it 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 the optimal revenue share of the Northern innovator is (positively) determined by the skill intensity of the intermediate goods z, and this result captures the spirit of the property right theory of the firm (Grossman and Hart, 1986; Hart and Moore, 1990). Appendix B shows that among the offshored products, the Northern innovators offshore more skill-intensive intermediate goods through their own affiliates and outsource less skill-intensive intermediate goods to Southern suppliers.

We then analyze the joint decisions of the Northern innovator on sourcing locations and ownership choices based on the comparison between the log profit ratios of the Northern and Southern productions with ownership choices ($N(z)$ and $S(z,\beta^O)$ for $O = F, D$). To formally characterize the patterns of global production and ownership structure, we assume the following:

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

This assumption essentially rules out the extreme cases in which all products are produced in one location. The first part guarantees that the most skill-intensive product $z = 1$ is produced in the North, in which the second part guarantees that the least skill-intensive product $z = 0$ is produced in the South.[10] Figure 2 plots the curves of log profit ratios $N(z), S(z, \beta^D)$, and $S(z, \beta^F)$, while Appendix C discusses the properties of these curves in detail. The optimal choice of the innovator is the upper contour of the three log profit ratios. Based on this assumption, we present our main proposition as follows:

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 produced through FDI offshoring ($z^*_{FN}(t) > z > z^*_{DF}$), and the less skill-intensive goods are outsourced to the South ($z < z^*_{DF}$). As offshoring cost t decreases, $z^*_{FN}(t)$ increases.*

The proof in Appendix C is largely in line with the findings of Antras (2005).[11] Figure 2 disentangles the role of comparative advantage and incomplete contracts in the global production sharing in an integrated framework. The horizontal axis presents the benchmark, namely, the log profit ratio of production in the South with complete contracts relative to itself. Thus, the upper contour of the curve $N(z)$ and the horizontal axis together characterize the global production sharing with the North-South cutoff $z^*(t)$ in a contractual frictionless world of Feenstra and Hanson (1996). To the left of the cutoff, the

[10]This assumption imposes an up-bound for β^F, that is, $\beta^F < \widetilde{\beta} \equiv f^{-1}(\omega_l/t)$, where $f(\beta) = \frac{1}{(1-\beta)}[\frac{1-\alpha}{1-\alpha(1-\beta)}]^{\frac{1-\alpha}{\alpha}}$. The intuition for this upper bound 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. $f(\beta)$ is an increasing function. Therefore, if β^F satisfies this inequality, then this inequality also holds for β^D. Given that the up-bound depends on ω_l and t, this assumption is more likely to hold if the offshoring cost is low, given ω_l.

[11]This proposition shows the pattern in which three production modes coexist. However, FDI offshoring may not exist under certain conditions. Figure 2 provides a sufficient frameworks for conducting a general analysis.

South specializes in less skill-intensive products because of her comparative advantage, while to the right of the cutoff, the North specializes in more skill-intensive products.

By contrast, the upper contour of the three curves for $N(z)$, $S(z, \beta^D)$, and $S(z, \beta^F)$ depicts global production sharing with incomplete contracts in the South. The comparative advantage still plays an important role, but incomplete contracts lead to an efficiency loss both at the intensive margin (a profit loss for any given z when production takes in the South) and extensive margin because less products would be offshored to the South due to the reduced profits of Southern production. With incomplete contracts, the North-South cutoff moves to $z^*_{FN}(t)$, and the product range between $z^*_{FN}(t)$ and $z^*(t)$ reflects the efficiency loss at the extensive margin. Importantly, these products that are potentially offshorable to the South are skill intensive and are thereby relevant for high-skilled labor. Moreover, the area between the upper contour of $\{S(z, \beta^D), S(z, \beta^F)\}$ and the horizontal axis reflects the efficiency loss at the intensive margin due to the incomplete contracts in the South.

2.3 Ownership Liberalization and Offshoring Cost

The model developed above can be applied to analyze the effects of ownership liberalization and reduction in offshoring cost on the patterns of offshoring. Figure 3 shows that a decline in offshoring cost can be captured by shifting down the curve $N(z)$ from the solid line to the dotted line. Initially, when offshoring cost is high, the equilibrium is at z^*_{DN}, that is, the Northern innovator only outsources limited low skill-intensive products through arms' length contracting because a high offshoring cost dampens the comparative advantage of production in the South. No FDI offshoring occurs even if foreign ownership is legally allowed. As the offshoring cost declines, when $N(z)$ moves to the right of the intercept of $S(z, \beta^D)$ and $S(z, \beta^F)$, the MNC finds it profitable to offshore more skill-intensive products to the South through their foreign affiliates. The model suggests that when both organization forms coexist as shown in Figure 2, reductions in offshoring costs have a stronger effect on FDI offshoring than on arm's length offshoring in terms of export revenue. While Appendix D presents the proof of this result, the intuition is straightforward. Given that the revenue elasticities of offshoring cost is $-\alpha/(1-\alpha)$ for both ownership types, a decline in offshoring cost increases the intensive margin of each firm type proportionally for any given z. However, a reduction in offshoring cost also increases the extensive margin of FDI offshoring but not the arm's length transactions. As a result, the export share of FDI offshoring increases with a decreasing offshoring cost.

Our model also provides a framework for analyzing the impact of ownership restriction and liberalization of MNCs on the offshoring pattern and skill demand in the South. Governments in developing countries often interfere with the ownership structures of MNCs for several reasons including reducing competition with indigenous firms, promoting technology transfer through joint ventures, and protecting strategic sectors (e.g., Kobrin, 1987; Gomes-Casseres, 1990). Figure 4 illustrates that when foreign ownership is prohibited, the FDI offshoring curve $S(z, \beta^F)$ is no longer in the MNC's choice set. The global production sharing settles at the intercept of $S(z, \beta^D)$ and $N(z)$, where goods within $[0, z^*_{DN}]$ are offshored to the South through arm's length transactions and all remaining production takes place in the North. Ownership liberalization can realize significant efficiency gains. When FDI offshoring becomes available, arm's length offshoring reduces to $[0, z^*_{DF}]$, FDI offshoring expands to $[z^*_{DF}, z^*_{FN}]$, and the total offshoring to the South grows by $[z^*_{DN}, z^*_{FN}]$. Therefore, relaxing ownership restrictions promotes a skill upgrade by relocating more skill-intensive production to the South. Accordingly, the expansion of FDI offshoring generates efficiency gains for the economy–as reflected by the triangle area below $S(z, \beta^F)$ and above $S(z, \beta^D)$ and $N(z)$–through optimizing the ownership structure.[12] The following proposition summarizes our findings:

Proposition 2 *If the offshoring cost is relatively low, the ownership liberalization and reduction in offshoring cost both increase the North-South production cutoff, that is, shifting more*

[12] These analyses are applicable to the scenario in which both forms of offshoring coexist, a situation that characterizes the empirical environment of China in the later empirical analysis.

skill-intensive products to the South through FDI offshoring, thereby increasing the share of FDI offshoring.

2.4 Skill Premium

The model suggests a set of mechanisms through which institutions and offshoring costs affect skill demand, and thereby the skill premium, in the South. First, we show the property of relative skill demand for a given intermediate good. For simplicity of exposition, we omit the superscript S that denotes the South.

Proposition 3 *The relative demand for high-skilled labor for each product z, that is, $h(z,\beta)/l(z,\beta) = \frac{\beta z}{(1-\beta)(1-z)}\frac{w}{q}$, increases in z and β but decreases in the relative wage of high-skilled labor.*

This proposition indicates two channels through which offshoring increases skill demand in the South. The first is the extensive margin in which skill demand increases when more skill-intensive intermediate goods with higher z are offshored to the South. The second is the intensive margin in which for given product z, a higher value of β associated with the bargaining power of the MNC also increases the firm's demand for high-skilled labor. We then define the aggregate relative 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, $\Psi = \{\{\beta^D\}, \{\beta^D, \beta^F\}\}$. $\Omega_\Psi = [0, z^*_{DN}]$ 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 derive the following proposition:

Proposition 4 *(1) A reduction in offshoring cost raises the cutoff between North-South production, which in turn increases the aggregate relative skill demand in the South.*
(2) If offshoring cost is relatively low and $0 < \alpha \leq 1/2$, the ownership liberalization for multinationals increases the aggregate relative skill demand in the South.

(3) Ceteris paribus, ownership liberalization and a reduction in offshoring cost increase the skill premium in the South.

The proofs are presented in Appendix E. Proposition 4 (1) shows the Feenstra-Hanson mechanism where the aggregate relative skill demand increases when more products are offshored to the South. This effect exists even in the presence of ownership restrictions. However, the increase in skill demand is limited when arm's length outsourcing is the only option. Proposition 4 (2) presents the Antràs' ownership mechanism. After removing the ownership restriction, the aggregate relative skill demand increases through both the extensive and intensive margins. In this case, more skill-intensive products are offshored by foreign affiliates, and the skill demand increases when firms switch from arm's length offshoring to FDI offshoring.

Given that the aggregate relative skill demand has a downward slope with $0 < \alpha \leq 1/2$, and with the assumption of an exogenously given relative skill supply, the skill premium increases as the aggregate relative skill demand shifts upward due to ownership liberalization or a reduction in offshoring cost. Therefore, Proposition 4 (3) follows.

3 Data and Empirical Strategy

Our empirical strategy centers on a two-step procedure developed from Proposition 2 on the determinants of FDI offshoring and Proposition 4 on the effects of offshoring on skill premium. We test the results by using an augmented Mincer earnings function that connects the aggregate demand for skill to an empirical specification that is amenable for estimating the impact of offshoring on wage inequality. We also describe the three datasets that we used for the empirical analysis and explain the measurement of two key explanatory variables, namely, FDI ownership liberalization and offshoring costs, both of which are related to Chinese institutions and geography.

3.1 An Augmented Mincer Equation

The Mincer wage equation is widely used in analyzing the effects of investment in schooling and skill on individual earnings. Our empirical specification builds on the following basic form:

$$\ln W\left(C, \mathbf{\Phi}\right) = \alpha_0 + \alpha_1 C + \boldsymbol{\alpha}_2' \mathbf{\Phi} + \varepsilon, \tag{6}$$

where $W\left(C, \mathbf{\Phi}\right)$ is the individual wage income at schooling level C and personal characteristics $\mathbf{\Phi}$. In our study, C is a dummy variable for college graduates, which correspond to high-skilled workers. Meanwhile, those without college education correspond to low-skilled workers. $\mathbf{\Phi}$ is a vector of other personal attributes that affect earnings, including labor market experience, experience squared, gender, and a dummy variable for employment in the state sector. ε is a mean zero residual $E(\varepsilon|C, \mathbf{\Phi}) = 0$.

The coefficient of the dummy variable of schooling represents college wage premium in percentage terms, that is, $\alpha_1 = E(\ln W|C = 1, \mathbf{\Phi}) - E(\ln W|C = 0, \mathbf{\Phi}) = ln(q/w)$, where q and w are the market equilibrium wages for college and non-college workers in the South as specified in equation (3). Equation (5) implies that the college wage premium increases along with the aggregate relative skill demand through its inverse function $ln(q/w) = lnD^{-1}(t, \Psi)$, where a decline in offshoring cost t and an expansion in an MNC's offshoring ownership choice set Ψ can both increase the skill premium α_1 as stated in Proposition 4. Hence, we obtain an augmented Mincer wage equation that takes into account the effects of offshoring on college wage premium:

$$\ln W\left(C, \mathbf{\Phi}, t, \Psi\right) = \alpha_0 + \alpha_1(t, \Psi) C + \boldsymbol{\alpha}_2' \mathbf{\Phi} + \epsilon. \tag{7}$$

3.2 A Two-Stage Procedure

While equation (7) implies a direct connection between (t, Ψ) and college wage premium, our offshoring model provides a structural framework that allows a deeper investigation into the mechanisms through which offshoring affects the skill premium. Proposition 2 suggests that falling offshoring costs and relaxing controls on an MNCs' ownership choice increase not only the total offshoring but also the share of FDI offshoring. Therefore, in the first stage, we assess the role of (t, Ψ) in determining the level and composition of offshoring:

$$lnR^O = lnR^O(t, \Psi), \tag{8}$$

where R^O is the revenue of processing exports by region and industry for firm ownership O, where $O \in \{D, F\}$ can be either domestic or foreign owned. The testable hypothesis from Proposition 2 posits that a reduction in offshoring cost, along with the policies that encourage foreign ownership, has a stronger positive effect on FDI offshoring relative to arm's length outsourcing.

In the second stage, we estimate an augmented Mincer regression that includes the interaction terms of the college indicator C with regional total offshoring (R) and share of FDI offshoring (RS^F) as follows:

$$\ln W\left(C, \mathbf{\Phi}, t, \Psi\right) = \alpha_0 + \left(\alpha_{10} + \alpha_{11} R + \alpha_{12} RS^F\right) \times C + \boldsymbol{\alpha_2'} \mathbf{\Phi} + \epsilon. \tag{9}$$

Propositions 2 and 4 suggest that the coefficients (α_{11} and α_{12}) estimated for both interaction terms are positive. The first coefficient presents a test for the Feenstra-Hanson mechanism in which the skill premium increases when more productions are offshored to the South. The second coefficient sheds light on the Antràs ownership mechanism for the composition of offshoring. Conditional on total offshoring, the transfer of skill-intensive products by MNCs' foreign affiliates to the South has an additional positive effect on skill premium.

The two-stage identification strategy directly tests the main propositions (2) and (4) of our model. The first stage assesses the effects of a reduction in offshoring cost and the ownership liberalization of MNCs on the patterns of offshoring, while the second stage identifies the types of offshoring that matter for the skill premium. As another advantage, this strategy deals with the selection bias of MNCs where these companies choose regions for offshoring based on local conditions, such as the quality of labor force and other unobserved regional characteristics. In practice, our two-stage procedure offers a natural instrument variable approach (IV) to deal with this selection issue. We use the exogenous variables (t, Ψ) to predict the variables (R, RS^F) in equation (8), which can serve as the instrument variables and help mitigate the endogeneity problems in estimating the effects of offshoring on the premium in equation (9). We address these specification issues and deal with the ability bias embedded in the estimation of Mincer regressions in later empirical analyses.

To explore the rich spatial variations in exposure to trade shocks, we implicitly assume low labor mobility across regions in China. If labor is freely mobile across regions, then market forces tend to equilibrate the skill premia across regions, thereby making it difficult to identify the effects of offshoring on wage inequality. The literature on regional adjustments to labor market shocks suggests that the response of mobility to the labor demand shocks across regions are slow and limited, particularly in developing countries such as China.[13] China has a household registration (or *Hukou)* system that imposes large costs to people who are working and living outside their *Hukou* region. According to Tombe and Zhu (2015), the average cost of inter-province migration is close to a worker's one-year income in 2000, while the migration cost in China only decreased slightly from 2000 to 2005. The large regional income disparity across Chinese provinces presents a good indication of how tightly migration costs bind. In our urban household survey data, the average wage ratios of the 90th to 10th percentile of provinces were 2.95 and 2.88 for non-college and college workers in 1992, respectively. By contrast, the corresponding ratios were around 1.5 on average for the two types of labor across the states in the US.

[13]Recently, several studies adopt the local market approach to explore the labor adjustments to trade shocks in advanced economy, such as the US (e.g., Autor et al., 2013), and developing countries, including Brazil and China (e.g., Dix-Carneiro and Kovak, 2015; Han et al., 2012).

These regional wage ratios increased slightly to 2.96 and 3.01 in 2006. Given the persistent regional wage gaps and limited labor mobility across Chinese provinces, we explore regional variations to identify the impact of offshoring on labor market outcomes.

3.3 Data and Policy Variables

We use three comprehensive data sources for our empirical analysis, namely, the ownership liberalization policy measure at the industrial level that we have constructed ourselves (1995-2007), trade data from Chinese customs (1992-2008), and the Chinese Urban Household Surveys (CUHS 1992-2006). Both the trade and labor datasets cover all provinces in mainland China except Tibet due to missing data 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 joint ventures, which was considered an effective way to learn management skills and the latest technologies from advanced foreign countries. However, wholly foreign ownership was restricted or prohibited in many manufacturing industries until China's accession to the WTO. For example, washing machines, refrigerators, and 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 Chinese government undertook a major legal and economic reform in regulating foreign investment in the late 1990s to remove foreign investment barriers. One major effort is revising the CGFII to relax the 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 reached their most significant levels around 2001. These policy reforms significantly changed the composition of foreign direct investment 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 by 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 the subsequent regression analysis, we construct two proxies for ownership liberalization at the industry level, namely, an encouragement policy indicator and a restriction (including prohibited) policy indicator. We assign a value of 1 to the encouragement (or restriction) policy in an industry if at least one product in that industry is formally stated on the government's encouragement (or restriction) list, that is, $EP_{it} = 1$ (or $RP_{it} = 1$); otherwise, we assign a 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 no policy is changed until a formal revision is announced in the published catalogue.[14]

We use two proxies to measure the reduction in offshoring cost. The first measure is the cumulative number of national policy zones.[15] Recent studies such as Wang (2013)

[14]See Sheng and Yang (2016) for a detailed discussion on the method of variable construction, the advantages and limitations of the indicator approach, and the exogenous nature of ownership policy changes.

[15]China started to establish special economic zones for its exports in coastal provinces in the early 1980s and later expanded these zones into inland provinces. These policy zones include an Economic and Technological Development Zone, High-Tech Development Area, Bonded Area, and Export Processing Zone. The 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.

show that the policy zones in China promote foreign investment and processing trade by reducing offshoring costs. For the second proxy, we follow Limão and Venables (2001) by using infrastructure or the (log) density of highway and railway, to approximate the reduction in offshoring costs.

The trade dataset records both the value and quantity of export at the product level (six-digit HS code), the locations and destinations of exporters, firm ownership types, and the types of Chinese custom regimes. Firm ownership types include Chinese-owned domestic firms, joint ventures, and wholly foreign-owned firms. We use processing export to measure the size of offshoring, use processing export by wholly foreign-owned firms to approximate FDI offshoring, and use processing export by other firms to measure arm's length offshoring. For the benchmark analysis, the North is represented by high-income countries based on the World Bank classification.[16] Table 1 presents the summary statistics of China's processing exports. The data reveal that processing exports play a major role in China's international trade and account for around 56 percent of the country's total exports from 1992 to 2008. Approximately 90 percent of processing exports during this period were shipped to high-income countries, and the shares of FDI exports in high-skilled industries exceeded those FDI exports in low-skill industries.

The CUHS data records the basic conditions of urban households and provides detailed individual information on the 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 15,000 to 56,000 workers in each sample year. We focus on the annual wages of manufacturing adult workers who engaged in wage employment. Wage income con-

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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 are collected from the China Development Zone Review Announcement Catalogue (NDRC, 2007).

[16]Our definition of high-income countries follows the World Bank's standard classification, which covers 66 countries. Taiwan is not included in the World Bank's classification even if it qualifies as a high-income region. We add Taiwan into our sample because this region is an important trade partner of mainland China. As a robustness check, we also use consider all of China's trade partners as North countries. All of our major empirical results hold for both samples.

sists of basic wage, bonus, subsidies, and other labor-related income from regular jobs. We compute real wage by deflating annual wages to the base year (2006) using province-specific urban consumption price indices.

4 Empirical Findings

4.1 Skill Content of Offshoring

We begin this section by examining the skill content of FDI offshoring and arm's length offshoring as proposed in Proposition 1. Figure 5(a) plots the evolution of the average skill intensity of two types of processing exports, where intensity is defined as the weighted average of industrial skill intensity, with the industrial shares of processing exports serving as the weights.[17] The intensity measure z_i for industry i is the employment share of workers with college degrees or above in total industrial employment based on the industrial employment information collected from the 1995 Chinese National Industrial Census (CNIC1995).[18] The figure shows that FDI offshoring is more skill intensive than arm's length offshoring and both types of processing exports show a significant skill upgrading from 1992 to 2008.

Figure 5(b) presents additional evidence on the distribution of skill intensity for processing exports by firm ownership type.[19] This figure reveals two important findings. First, the distribution of FDI processing exports is more skewed toward skill-intensive sectors than that of arm's length processing exports. In other words, the FDI processing exports first-order stochastically dominate those of other firms. This feature is more significant in 2008 than 1992. Second, processing exports, especially FDI processing, shows a

[17] The average skill intensity for the firm ownership type O in year t is defined as $\widetilde{z}_t^O = \sum_i z_i(R_{i,t}^O/\sum_i R_{i,t}^O) = \sum_i z_i * RS_{i,t}^O$, where $O = F, D$. z_i denotes the skill intensity of industry i, while $R_{i,t}^O$ and $RS_{i,t}^O$ denote the value and share of processing exports of industry i in year t for the given firm ownership type O.

[18] Appendix F2 shows more details on data measurement and concordance.

[19] The empirical distribution $\widehat{G}^O(z)$ is constructed as follows: $\widehat{G}_t^O(z) = \sum_i I(z_i \leq z) * RS_{i,t}^O$, where $I(.)$ is the indicator function.

significant skill upgrading because all distributions shift toward the right direction across the two years.

Following Delgado et al. (2002), we perform a non-parametric Kolmogorov-Smirnov (KS) test for the first-order stochastic dominance. We first conduct a two-sided KS test to examine the equality of the two distributions, namely, $G^F(z) = G^D(z)$. If the hypothesis is rejected, then perform a one-sided test to examine the first-order stochastic dominance, that is, $G^F(z) \leq G^D(z)$. If the hypothesis is not rejected, and given that $G^F(z) \neq G^D(z)$, we will conclude that $G^F(z) < G^D(z)$.

Panel A in Table 2 presents the p-values for implementing the KS test for each year from 1992 to 2008. The two-sided test rejects the null for years 1997 to 2008 at the 5 percent significance level, whereas the one-sided test does not reject the null for all years in our sample. The combined results confirm Proposition 1 that FDI processing exports are more skill intensive than arm's length processing exports for the years following 1997. The failure to reject equal skill content prior to 1997 is consistent with the high offshoring costs in those years when foreign ownership was restricted. Given that few foreign-owned firms entered the China market, their skill distributions are not statistically different from those of arm's length offshoring. However, with the decline in offshoring costs and the relaxation of restrictions on foreign ownership, MNCs offshored more intermediate goods through foreign affiliates. As a result, the differences in skill content became statistically significant.

This two-step KS testing procedure can be applied to examine the skill upgrading in the processing exports for each type of firm. Panel B in Table 2 presents the results for each five-year interval from 1992 to 2007. The two-sided test rejects the null at the 5 percent significance level, while the one-sided test fails to reject the null for all firms in three time regimes. These findings imply the significant skill upgrading in the processing exports for all firms. The processing exports by foreign-owned firms became more skill intensive than those by arm's length contracts only after 1997. Therefore, the skill upgrading of all firms was initially similar but became faster in FDI processing exports in later years.

We calculate the contribution of FDI processing exports to the skill content in total processing exports by computing the ratio of the skill content in FDI processing exports to that of total processing export, that is, $skshr_t^F = \sum_i z_i R_{i,t}^F / \sum_i z_i R_{i,t} = (\widetilde{z}^F/\widetilde{z})(\sum_i R_{i,t}^F / \sum_i R_{i,t}) = Z^F * RS_t^F$, where $Z^F = \widetilde{z}^F/\widetilde{z}$ is the relative average skill intensity of FDI processing exports in year t, and $RS_t^F = \sum_i R_{i,t}^F / \sum_i R_{i,t}$ is the revenue share of foreign owned firms in total processing exports. Our calculation reveals that FDI's weighted contribution has risen from 12 percent to approximately 70 percent of the total skill content in processing exports. Therefore, FDI is mainly responsible for the increase of the skill content in processing exports.[20]

4.2 Offshoring and Ownership Structure

Given that FDI processing exports are more skill intensive than arm's length offshoring, their composition and distribution have important implications for skill demand and skill premium. Accordingly, we examine different determinants of these two types of processing exports across regions and industries. In particular, we test whether offshoring cost reduction and ownership liberalization increase both the total processing exports and the proportion of FDI offshoring as predicted in Proposition (2).

Our model shows that the revenue of the MNC is log linear in offshoring cost, ownership type, and factor prices (see equation D.1 in Appendix D). For regression specification, the dependent variable $ln(R_{oijt})$ denotes the log value of processing exports of firm ownership type o in industry i, province j, and year t. To assess the effects of different policies, we interact the foreign ownership indicator variable F_{oijt} with the encouragement policy

[20]Data limitations prevent us from considering "within" industrial skill upgrading, such as in Hsieh and Woo (2005). Corroborative evidence from the National Economic Census in 2004 shows that the employment share of skilled workers in foreign-owned firms is higher than that in other firms (Chen et al., 2011). We match these census data with the Chinese firm-level customs data to identify all processing firms, and we find that the employment share of college graduates in wholly foreign-owned enterprises is 6 percentage points higher than that in other firms. This skill comparison is largely consistent with international evidence that foreign firms are relatively more skill and capital intensive than domestic firms.

(EP_{it}), the restriction policy (RP_{it}), and the measures of offshoring cost reduction ($Cost_{jt}$), to obtain the following regression:

$$
\begin{aligned}
ln(R_{oijt}) = \theta_0 + \theta_1 F_{oijt} + \rho_1 EP_{it} + \rho_2 RP_{it} + \rho_3 Cost_{jt} \\
+ (\gamma_1 EP_{it} + \gamma_2 RP_{it} + \gamma_3 Cost_{jt}) \times F_{oijt} + \boldsymbol{\theta_2'} \boldsymbol{X} + \xi_i + \xi_j + \xi_t + \epsilon_{oijt} \qquad (10)
\end{aligned}
$$

In this specification, the linear coefficients ρ shed light on the effects of industrial policy and offshoring cost variables on outsourcing processing export, while the coefficients γ capture the effects of these variables on FDI processing export relative to outsourcing. We focus on the magnitudes and signs of γ and expect $\gamma_1 > 0$, $\gamma_2 < 0$, and $\gamma_3 > 0$ because the cost is measured in transport infrastructure and number of policy zones. We also expect that the total effects of encouragement (restriction) policy and offshoring cost reduction have positive (negative) on processing exports. Although the model predicts a competition from the entry of foreign affiliates after ownership liberalization that can reduce outsourcing exports, we have not analyzed other empirically relevant counter-acting forces in our model. For example, the learning effects that are associated with knowledge spillovers from FOEs can neutralize the competition effect (Javorcik, 2004). Therefore, we must be cautious in interpreting the estimates for ρ, because this coefficient empirically captures the total effects of these opposing forces.

For control variables in $\boldsymbol{X}$, we follow Romalis (2004) by interacting factor endowment variables, physical and human capital, with industry-specific factor intensity.[21] To control for the role of institutions, we follow Nunn (2007) by including the interaction term between industry-specific contract intensity and quality of regional contract environment.[22]

[21] Industry-specific skill intensity is measured as the employment share of workers with college education, while capital intensity is measured as the ratio of fixed asset investment to output for the industry. Both variables are constructed based on data from the 1995 Chinese National Industrial Census. Provincial skill endowment is measured as the share of college workers in the population above the age of 6, while capital endowment is measured as the ratio of capital stock to output for the province. We are grateful to Chongen Bai for sharing estimates of capital stock data.

[22] Industry-specific contract intensity is proxied by the inputs share of the relationship-specific intermediates based on the Chinese input-output table. We are very grateful to Hong Ma for sharing the Nunn

To mitigate 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 of these variables. For ease of interpretation, all variables, except for the indicator variables, are de-meaned before we compute the interaction term. While ξ_i, ξ_j, and ξ_t are used to control for the industry, province, and year fixed effects, we also control for province-year fixed effect as an alternative specification to deal with unobserved time-varying provincial factors, such as local government policies and agglomeration. As a trade-off, the parsimonious control for province-year effects may lead to loss of estimates for the observed province time-varying variables, such as offshoring cost reduction measured at the provincial level.

We begin with a simple specification in Table 3 that only includes the interaction terms of organizational form with the key variables of ownership liberalization policy and offshoring cost and the 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 arm's length processing exports during the sample period, thereby indicating 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 effects on outsourcing processing exports, which holds true across alternative specifications. The offshoring cost reduction that is measured using both policy zones and infrastructure increase the outsourcing exports.

Column 1 shows the most important empirical findings through the four interaction terms with the FDI indicator. These interaction terms are designed to test the hypotheses developed in Proposition 2. The coefficient on $F \times EP$ is positive and statistically significant, thereby supporting the prediction that relaxing ownership restrictions increase

index. The provincial contract environment is measured using data from the Survey of Doing Business in 30 provincial capital cities in China (World Bank, 2008). Specifically, we use the "court cost" variable, which is the ratio of official costs of going through court procedures to debt claim. Higher "court cost" indicates an inefficient, rent-seeking legal system, implying a lower probability of upholding contracts between firms. For convenience of interpretation, we construct a court efficiency measure that equals to 0.5 minus the court cost variable. Therefore, a higher index value implies a more efficient contract environment.

FDI processing. By contrast, restriction policies reduce FDI processing exports relative to that of outsourcing. In addition, the positive and statistically significant coefficients on $F \times Policy\ zones$ and $F \times Infrastructure$ suggest that a lower offshoring cost increases the processing exports of FDI more than those of outsourcing as predicted by the proposition.

Column 2 of Table 3 presents the interaction terms of industry-specific factor intensities and provincial factor endowments. The positive coefficients of these interactions indicate the role of comparative advantage. Those regions with more abundant skilled labor (or capital) export more skill-intensive (or capital-intensive) products. Similarly, those provinces with better contract environments export more contract-intensive products. Compared with the specification in Column 1, the only noticeable change in the coefficients is that the policy zones have a reduced magnitude and statistical significance, which is likely correlated with provincial endowment variables. However, the effect of infrastructure on outsourcing exports remains positive and statistically significant.

To parsimoniously control for the other unobserved province-year varying factors that will otherwise appear as omitted variables in the error term, Column 3 adds province-year fixed effects. As a result, all province-year varying variables are removed from the regression due to collinearity. Under this preferred specification with more robust controls, the coefficients on ownership policy and offshoring cost remain stable. Quantitatively, compared with an industry that has no policy interventions, the implementation of encouragement policy in an industry increases FDI processing exports by 24.4 percent, while the implementation of restriction policy reduces FDI exports by 43.5 percent. Similarly, ownership policies do not significantly affect arm's length processing exports. Under this specification, a 1 percent increase in highway and railway density increases FDI processing exports by 0.21 percent relative to arm's length processing. Adding one more national policy zone in a province results in an 8 percent increase in FDI processing exports relative to arm's length processing. These estimates capture the average effects of policy and offshoring cost on processing exports across all industries.[23]

Because the role of FDI in processing exports differ across industries (see Table 1), we also run separate regressions for high- and low-skill intensive industries by using the sample mean of industrial college employment share as the threshold. Columns 4 and 5 of Table 3 present the estimation results. Overall, the effects of encouragement and restriction policies on FDI exports are stronger than that of outsourcing in high-skill intensive industries relative to low-skill intensive industries. Moreover, infrastructure and policy zones strongly enhance FDI processing exports in high-skill intensive industries. These findings are consistent with the model predictions.[24]

4.3 College Premium

The empirical evidence presented thus far has identified ownership liberalization and decline in offshoring cost as significant contributors to the rapid expansion of regional FDI offshoring, which is more skill intensive than arm's length offshoring. In the second stage of analysis, we test the implications of Proposition 4 by estimating the local labor market outcomes of the exposure to FDI and arm's length offshoring based the augmented Mincer wage regression. Building on equation (9), we estimate the following expanded form:

$$ln(W_{mjt}) = \alpha_0 + [\alpha_{10} + \alpha_{11} R_{jt} + \alpha_{12} RS^F_{jt} + \boldsymbol{\alpha'_{13}} \boldsymbol{V}_{jt}] \times C_{mjt} + \boldsymbol{\alpha'_2} \boldsymbol{\Phi}_{mjt} + \delta_{jt} + \varepsilon_{mjt}, \quad (11)$$

[23]The log specification in equation (10) drops all zero export values, thereby leaving out useful information from the data or generating potential bias due to the heteroskedastic multiplicative error. We follow Silva and Tenreyro (2006) by adopting the Poisson pseudo-maximum likelihood (PPML) estimation, which uses the level of trade flow as the dependent variable including the zero values. The effects of ownership policy and offshoring cost reduction on FDI processing exports remain strong in this alternative specification.

[24]Interestingly, the encouragement policy also increases outsourcing processing exports in high-skill industries. This result is consistent with a positive spillover effect from FDI processing export to outsourcing or other preferable treatments with the encouragement policy. By contrast, the restriction policy has a negative impact on outsourcing processing exports in low-skill intensive industries.

where $\ln(W_{mjt})$ is the log real annual wage for individual m in province j and year t, C_{mjt} is the college indicator which interacts with regional total offshoring scaled by industrial output (R_{jt}) and the share of FDI offshoring (RS^F_{jt}), and $\mathbf{\Phi}$ is a set of personal characteristics including gender, potential labor market experience, experience squared, and a dummy variable for state sector employment. While the coefficient α_{10} is the conventional measure of college premium, the inclusion of R_{jt} and RS^F_{jt} takes into account the demand for skill from offshoring in local labor markets. This specification captures both the aggregate relative skill demand when more products are offshored to the South (the Feenstra-Hanson mechanism through α_{11}) and the composition effect of processing exports (the Antràs' ownership mechanism through α_{12}). Proposition 4 postulates that those regions with more processing exports and higher shares of FDI offshoring experience a stronger demand for skill and therefore realize an increase in their college premium, i.e., $\alpha_{11} > 0$ and $\alpha_{12} > 0$.

Equation (11) also controls for the other determinants of the skill premium at the provincial level through the interaction term $\boldsymbol{V}_{jt} \times C_{mjt}$. The first factor reflects the Stolper-Samuelson theorem in which the relative wage of unskilled workers increases in regions with abundant low-skilled workers as they export more low-skill intensive final goods. We use the ratio of ordinary exports to industrial output to capture the exports of final goods. The second determinant of relative wage is skill-biased technological changes (SBTC; see for example, Bound and Johnson, 1992; Acemoglu, 1998), which are measured as the ratio of R&D expenditure to aggregate output, while the third determinant is capital-skill complementarity (Krusell et al., 2000), which is measured as capital-to-output ratio at the province level. We also include province-year pair dummies δ_{jt} to capture the province-and-year differences in the determinants of wage income. Accordingly, we adopt province-year cluster robust standard errors to control for sample dependence.

Ordinary least squares (OLS) is widely used to estimate the Mincer earnings function. However, the OLS estimation of (11) presents two concerns, namely, (a) the two key variables $\{R_{jt}, RS^F_{jt}\}$ are potentially endogenous to local labor market conditions, and (b) the omission of an individual's ability in the specification may result in a biased and inconsistent estimate of the college premium due to the positive correlation between schooling and ability. With regard to (a), if MNCs with global production choose to offshore or establish their foreign affiliates in regions with abundant high-skill and high-quality workers, then the locational selection implies positive biases in the estimates for the interaction terms. To mitigate the possible endogeneity, we adopt a two-stage IV approach (Angrist and Pischke, 2008). First, we construct the predicted values of processing export-to-output ratio $\widehat{R}_{jt}$ and the share of FDI processing exports $\widehat{RS^F_{jt}}$ from the determination of processing exports as follows:

$$\widehat{R}_{jt} = \sum_{i,o} exp(\widehat{lnR_{oijt}})/ind\_output_{jt}$$
$$\widehat{RS^F_{jt}} = \sum_{i,o=F} exp(\widehat{lnR_{oijt}})/\sum_{i,o} exp(\widehat{lnR_{oijt}})$$

where $\widehat{lnR_{oijt}}$ is predicted from regression (10) based on the preferred specification in Column 3 of Table 3. We use these predicted values as instrumental variables for R_{jt} and RS^F_{jt} in the augmented Mincer regression. These predicted values constitute legitimate instruments because the key determinants of processing exports by type, including ownership liberalization policies, national policy zones, and infrastructure, are plausibly exogenous to labor force characteristics. Figure F.1 of Appendix F.2 presents the scatter plots of the actual and predicted values of processing export ratio and the share of FDI processing export, which show close correlations. While this two-stage regression generates consistent estimates on the coefficients of interest, the estimated standard errors are incorrect. Therefore, we use the non-parametric bootstrap method to obtain the standard errors. To address concern (b), we perform a series of sensitivity tests, including cohort analysis, to check for potential ability bias. As will be explained later, our results suggest that the ability bias does not significantly affect our main findings.

Table 4 presents the estimation results for the determinants of earnings by using the CUHS data from 1992 to 2006. [25] Column (1) starts with the OLS estimates of the basic regression. The interaction terms of offshoring variables $\{R_{jt}, RS^F_{jt}\}$ with the college indicator are added to Column (2), and additional controls for ordinary export, R&D expenditure share, and capital-output ratio are included in Column (3). The two remaining columns present the IV estimates of (2) and (3) along with the predicted values of $\{\widehat{R}_{jt}, \widehat{RS^F_{jt}}\}$.

Several findings emerge from the basic specification. First, workers with college education earn a 35 percent wage premium relative to workers without college education. Second, the returns to experience for Chinese workers exhibit a typical concave profile, where one year of experience increases a worker's real wage by 4.8 percent at the beginning of their careers. Third, the average wage of female workers is 20.2 percent less than that of male workers, thereby indicating a significant gender earnings gap. Fourth, workers in the state sector earn a 19.5 percent wage premium compared with their counterparts in non-state sectors. These estimates on experience-earning profiles, gender earnings gap, and state-sector wage premium are stable across all specifications and consistent with the findings of existing studies on the Chinese labor market.[26]

The most important empirical findings on wage inequality are presented through the interaction terms of the college indicator with the two offshoring variables $\{R_{jt}, RS^F_{jt}\}$. Each of these coefficients reported in Columns (2) to (4) are positive and statistically significant, thus supporting Proposition 4, which posits that both the scale of offshoring and the share of FDI offshoring are important for the local demand for skill and contribute to an increase in college premium. While the coefficients for ordinary exports, R&D expenditure share, and capital-to-output ratios are statistically insignificant in the biased OLS specification, each of the coefficients becomes statistically significant in Column (5) in the IV specification. In a test for weak instruments, the F-test statistics in the first stage are

[25] See Table F.3 for the summary statistics of household characteristics and related provincial variables.

[26] See Ge and Yang (2014) for a recent analysis of China's wage structure and the references cited therein.

all above the Stock-Yogo criteria of 10, thus rejecting the notion of weak instruments and giving support to (5) as the preferred specification. Compared with the basic OLS regression, the coefficient for the college indicator drops from 35 percent in Column (1) to 22.1 percent in column (5). The interaction terms with the college indicator help identify the mechanisms through which local labor market variables affect the college premium.

The IV estimates in Column (5) provide the basis for assessing the driving forces behind the rising college premium in China's manufacturing sector. Quantitatively, one percentage point increase in the ratio of processing export to local industrial output and in the share of FDI processing export increases the college wage premium by 0.534 and 0.295 percentage points, respectively. The export of ordinary goods, R&D expenditure share, and capital stock of local economies also play significant roles in shaping college premium. One percentage point increase in the ratio of ordinary exports to industrial output reduces the returns to college by 0.264 percentage point, which is consistent with the Stolper-Samuelson theorem that the exports of labor-intensive goods increase the relative wage of unskilled labor. Meanwhile, one percentage point increase in R&D expenditure share and capital-output ratio is associated with a 1.548 and 0.025 percentage point increase in college premium, respectively. These findings confirm the positive effects of skill-biased technological change and capital-skill complementarity on college premium.

After ownership restrictions were liberalized in China following the country's accession into the WTO, the wage of college graduates relative to non-college graduates (log wage differential) in China's urban manufacturing sector increased by about 14.9 percentage points between 2000 and 2006. During this period, the ratios of processing and ordinary exports to industrial output barely changed, thereby making their quantitative contributions to the rising college premium insignificant. By contrast, the share of FDI processing exports increased by approximately 25 percent, thereby contributing to nearly 50 percent $(25 \times 0.295 = 7.375)$ of the observed increase in the college premium. Moreover, the empirical estimates on the determinants of processing exports in Section (4.2) suggest that 17 out of the 25 percentage point increase in the share of FDI processing exports were attributable to the ownership liberalization of MNCs and the reduction in offshoring cost. These estimates imply that the FDI processing exports resulting from these two factors account for 33.7 percent of the increase in the college premium.[27] Our findings suggest that the composition of offshoring through the Antràs' ownership mechanism plays a more significant role than the scale of offshoring through the Feenstra-Hanson's channel in increasing the skill premium in China during this period.

From 2000 to 2006, the R&D expenditure and capital-output ratios increased by 0.5 and 8 percentage points, thus contributing to 5.19 $(0.774/14.9)$ and 1.34 $(0.025/14.9)$ percent of the rising college premium, respectively. Two reasons might help explain their limited contributions in the context of the literature (e.g., Ge and Yang, 2014), which studies the wage structure of the aggregate economy. First, our analysis only focuses on the manufacturing sector where international trade plays an important role; therefore, domestic R&D expenditures may not have a major impact on the SBTC. Second, FDI offshoring can capture part of the SBTC because FDI is considered a source of technology upgrading in developing countries (Acemoglu et al., 2015). Disentangling these factors present challenging tasks, which we will leave for future research.

4.4 Sensitivity Analysis

The estimation of schooling returns can be biased due to specification errors. First, we examine the robustness of our results to omitted ability, which is likely correlated with the educational attainment of an individual. Given that CUHS data do not report variables, such as individual dates of birth, parental schooling, and sibling composition, that

[27] Hale and Long (2012, chap. 4) presents show that firms with higher shares of foreign ownership pay higher average wages to their skilled workers, and the presence of foreign firms impose an upward pressure on the wages of workers of neighboring domestic firms, especially for skilled workers. Yang (2005) reports that schooling returns are higher in Chinese cities with a greater degree of openness as measured by the percentage of workers employed in foreign and joint-venture firms, which can either generate higher demand for skills or create a driving force for competitive wage compensation. This empirical evidence provides additional support for the role of foreign firms in the determination of schooling returns in China.

are potential instruments for the college indicator, we focus instead on the birth cohort who was eligible for college education during the Cultural Revolution (CR) (1966-1976) as a robustness check. Because college entrance examinations were abolished during CR, the selection of youth into college was politically oriented and independent of the innate abilities of the candidates for learning. Park et al. (2015) find that CR was an equalizer of educational access, and that the educational attainment of youth in cities became much less correlated with that of their parents compared with other cohorts before or after CR. To implement an approach with a limited ability bias, we separate the cohorts born between 1947 and 1957 who would enter college during CR from all other birth cohorts. Afterward, we run two separate wage regressions with the preferred specification (5) in Table 5 for the two worker groups.

Columns 1 and 2 of Table 5 show that the college graduates earn a substantially higher wage premium (26.1%) among the non-CR cohorts than college premium (13.3%) among the CR cohorts. The lower returns to college for the CR cohort is consistent with the absence of ability bias in the estimation, but we cannot rule out the possibility of a lower quality of education during CR, thereby leading to lower returns. Importantly, the estimates for the two key interaction terms of college with the ratio of processing exports and the share of FDI exports remain positive and statistically significant, with their magnitudes (0.348, 0.301) and (0.498, 0.256) being similar to the preferred baseline estimates (0.534, 0.295) presented in Table 5. Therefore, our main finding, that is, an increase in processing exports and FDI exports increases the returns to college, remain robust to the controls for unobserved ability.

Second, the labor market participation of women in China declined significantly over the sample period (Ge and Yang, 2014). Given that the change in labor force composition can lead to potential complications and that the effects of processing and FDI exports may not be gender neutral, we also estimate the earnings function by separating the male and female samples. The results in columns (3) and (4) indicate that the college premium is larger among women (30.2%) relative to men (18.7%). Given these differences, we reconfirm the results that an increase in processing exports and in the share of FDI exports will increase the college premium for both men and women. Processing exports have a larger effect on the returns to college for women, whereas FDI exports have a larger effect on the college premium for men. Both findings lend support to proposition 4.

Third, we use years of schooling as the measure of skill and explore the effect of processing export and its composition on schooling returns. We find that both the size of processing exports and the share of FDI processing have significantly positive effects on returns to education as shown in Table F.1. Consistent with our benchmark results in column (5) of Table 5, we also find the highly significant effects of SBTC on schooling returns and capital-skill complementarity.

Fourth, we use the processing exports to all trade partners of China instead of exports to only high-income countries as our sample for the regression. This alternative sampling scheme takes into account the possibility that the outsourced products to China may not be necessarily shipped back to the Northern innovator but can be sold to other countries. All estimates reported in the last column of Table 5 are broadly consistent with our benchmark findings. These results are not surprising because China's exports to high-income countries accounted for approximately 90% of its total processing exports during the sample period (see Table 1).

5 Concluding Remarks

This paper studies a new mechanism through which the composition of offshoring from developed economies affects the wage inequality in developing countries. Using data from China's processing exports, we find evidence of a higher skill intensity in FDI offshoring than in arm's length offshoring. When China relaxed its ownership restrictions on MNCs and lowered its offshoring costs upon its accession to the WTO, more skill intensive production were shifted to the World's Factory through the affiliates of MNCs, thereby increasing the relative demand for high-skilled labor. Our empirical analyses reveal that an increase in FDI processing exports contributes to approximately one-third of the increase in the college premium in China's manufacturing sector between 2000 and 2006. This finding highlights the role of the organizational structure of offshoring in shaping the skill content of trade and factor prices in developing countries.

The theory and evidence presented in this paper also have direct policy implications for FDI and technology transfer to developing countries (e.g., Harrison et al., 2010). In the globalized economy, offshoring involves the complex interactions between MNCs and the governments in the South. In the case of China, those industrial policies that impose joint-venture requirements and technology sharing are often ineffective in attracting foreign investments and advanced technologies because MNCs tend to choose low-skill arm's length transactions under such policies and institutions. By contrast, if the host country governments opt to improve the quality of their institutions, such as enhancing contractual enforcement, relaxing ownership restrictions on FDI, and reducing offshoring costs, MNCs have strong incentives to choose FDI offshoring with advanced products and technologies. The expansion in skill-intensive offshoring in turn increases the returns to skill in the South, thereby inducing human capital investment and enhancing economic growth in the long run.

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Table 1: Summary Statistics of China's Processing Exports

Year	Processing exports		Share in processing exports		FDI's share in		
	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 from the 1995 Chinese National Industrial Census to measure skill intensity at the industry level. High-skill industries refer to skill intensity above the sample mean.

Table 2: 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 processing exports
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)	Distribution in (t+5) weakly dominates distribution 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
	(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 $\times$ Enc. policy	0.244***	0.244***	0.244***	0.751***	0.180***
	(0.055)	(0.055)	(0.055)	(0.115)	(0.059)
FDI $\times$ Res. policy	-0.448***	-0.441***	-0.435***	-0.520***	-0.156**
	(0.060)	(0.060)	(0.060)	(0.079)	(0.076)
FDI $\times$ Natl. policy zones	0.078***	0.082***	0.080***	0.088***	0.075***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
FDI $\times$ Infrastructure	0.205**	0.186**	0.209**	0.301**	0.191*
	(0.089)	(0.091)	(0.093)	(0.118)	(0.098)
Skill intensity $\times$ Skill endowment		0.857***	0.862***	0.491***	0.569*
		(0.081)	(0.081)	(0.102)	(0.293)
Capital intensity $\times$ Capital-output ratio		0.006**	0.006**	0.004	0.004
		(0.003)	(0.003)	(0.004)	(0.003)
Contract intensity $\times$ Court efficiency		0.140***	0.141***	0.166***	0.152***
		(0.012)	(0.012)	(0.014)	(0.017)
Industry FE	+	+	+	+	+
Province and year FE	+	+			
Province-year FE			+	+	+
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 province-year cluster robust standard errors are enclosed in parentheses. *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

[a] Province-year varying factors, such as skill endowments and capital-output ratio, are included in the regression. Given their insignificant coefficients, they are not reported in the table.

Table 4: Determinants of College Premium in China's Manufacturing Sector: 1992-2006

	OLS			IV[a]	
	(1)	(2)	(3)	(4)	(5)
College indicator	0.350***	0.251***	0.214***	0.256***	0.221***
	(0.009)	(0.011)	(0.031)	(0.010)	(0.022)
College indicator interaction terms					
College × Processing exports ratio		0.440***	0.492***	0.489***	0.534***
		(0.140)	(0.145)	(0.122)	(0.132)
College × Share of FDI processing exports		0.315***	0.316***	0.284***	0.295***
		(0.043)	(0.045)	(0.050)	(0.049)
College × Ordinary exports ratio			-0.202		-0.264*
			(0.224)		(0.137)
College × R&D ratio			0.904		1.548***
			(0.869)		(0.475)
College × Capital-output ratio			0.029		0.025*
			(0.024)		(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)
Province-year FE	YES	YES	YES	YES	YES
First stage F-stat				$>$ 190.41	$>$ 237.72
Observations	156,658	156,658	155,905	143,010	143,010
R-squared	0.366	0.368	0.369	0.297	0.303

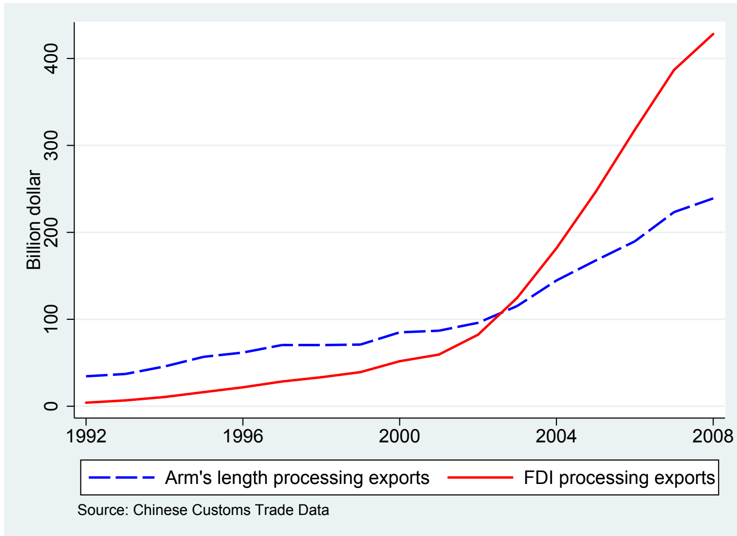
Note: The dependent variable is log (annual wage income). The province-year cluster robust standard errors are enclosed in parentheses for column (1)-(3). *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

[a] Columns (4) and (5) are estimated by GMM, where we use the constructed processing exports ratio and the share of FDI processing exports as instruments. The bootstrapped standard errors are enclosed in parentheses.

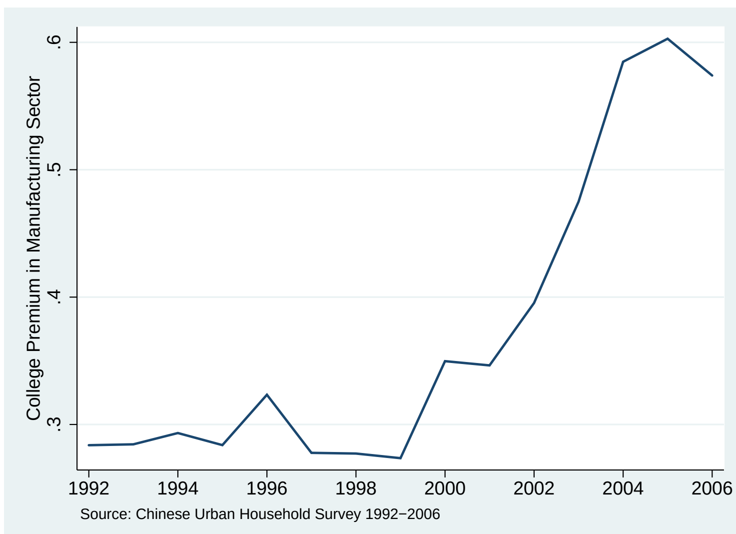
Table 5: Sensitivity Analysis on the Determinants of College Premium

	Cultural Revolution cohort	Non-CR cohort	Male only	Female only	All trade partners
	(1)	(2)	(3)	(4)	(5)
College indicator	0.133***	0.261***	0.187***	0.302***	0.219***
	(0.038)	(0.024)	(0.031)	(0.036)	(0.019)
College indicator interaction terms					
College × Processing exports ratio	0.348*	0.498***	0.440***	0.785**	0.482***
	(0.179)	(0.176)	(0.145)	(0.272)	(0.144)
College × Share of FDI processing exports	0.301***	0.256***	0.333***	0.190**	0.285***
	(0.082)	(0.058)	(0.058)	(0.075)	(0.058)
College × Ordinary exports ratio	-0.382	-0.071	-0.479**	0.370	-0.153
	(0.286)	(0.202)	(0.195)	(0.320)	(0.206)
College × R&D ratio	0.216	2.007***	1.794**	0.678	1.226***
	(0.811)	(0.634)	(0.877)	(0.867)	(0.488)
College × Capital-output ratio	0.056*	0.010	0.034	-0.013	0.024*
	(0.026)	(0.016)	(0.018)	(0.023)	(0.013)
Individual characteristics					
Experience	0.039***	0.044***	0.052***	0.047***	0.047***
	(0.005)	(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	-0.217***	-0.205***			-0.209***
	(0.006)	(0.005)			(0.003)
State owned sector	0.243***	0.170***	0.151***	0.235***	0.194***
	(0.006)	(0.005)	(0.005)	(0.006)	(0.004)
Province-year FE	YES	YES	YES	YES	YES
First stage F-stat	>271.72	>224.91	>248.29	>216.38	>177.48
Observations	51,775	91,235	79,086	63,924	143,010
R-squared	0.296	0.300	0.287	0.265	0.303

Note: The dependent variable is log (annual wage income). The regressions are estimated by GMM using the constructed processing exports ratio and the share of FDI processing exports as instruments. The bootstrapped standard errors are enclosed 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

Figure 1: Processing Exports and College Premium in China

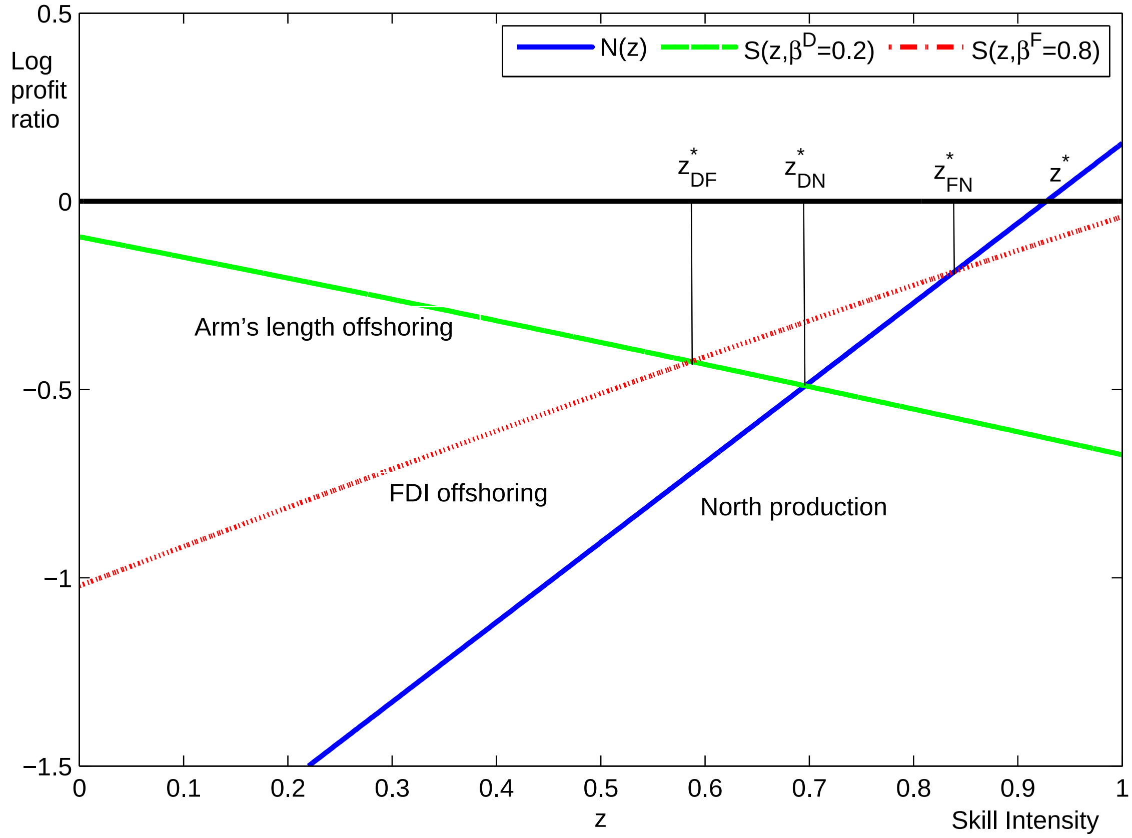


Figure 2: Optimal Ownership of Offshoring and Skill Intensity of Intermediate Goods

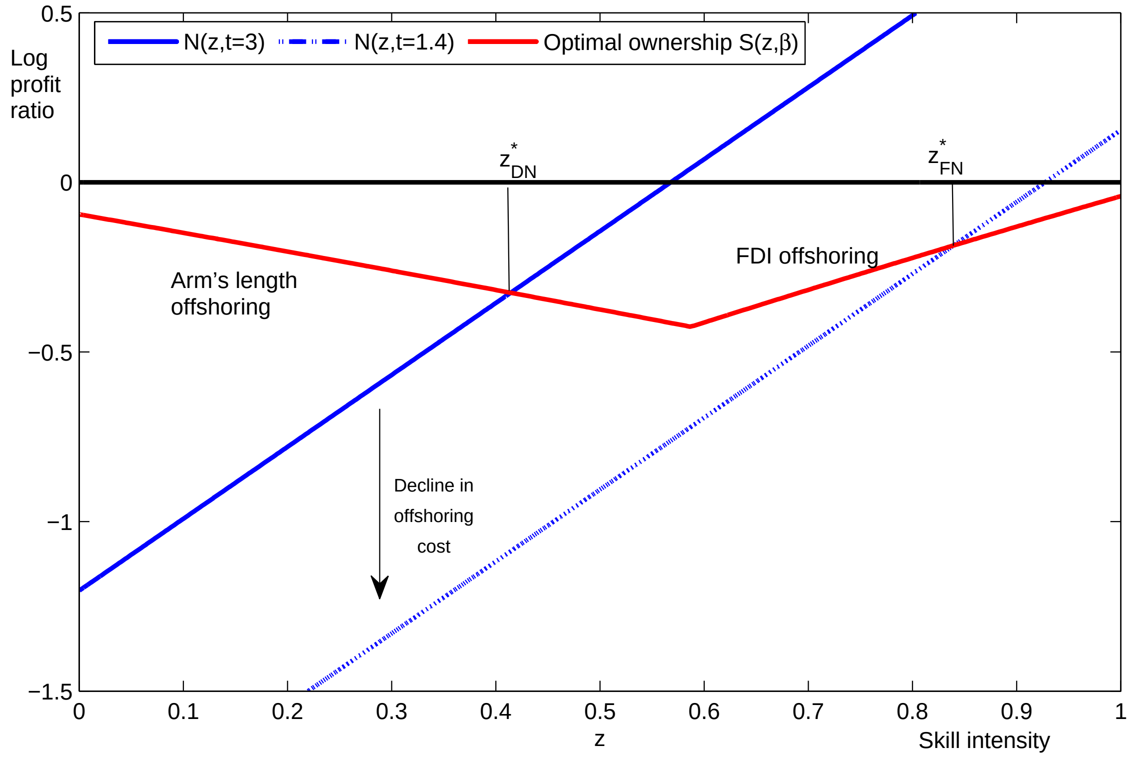


Figure 3: Reduction in Offshoring Cost and Skill Intensity of Intermediate Goods

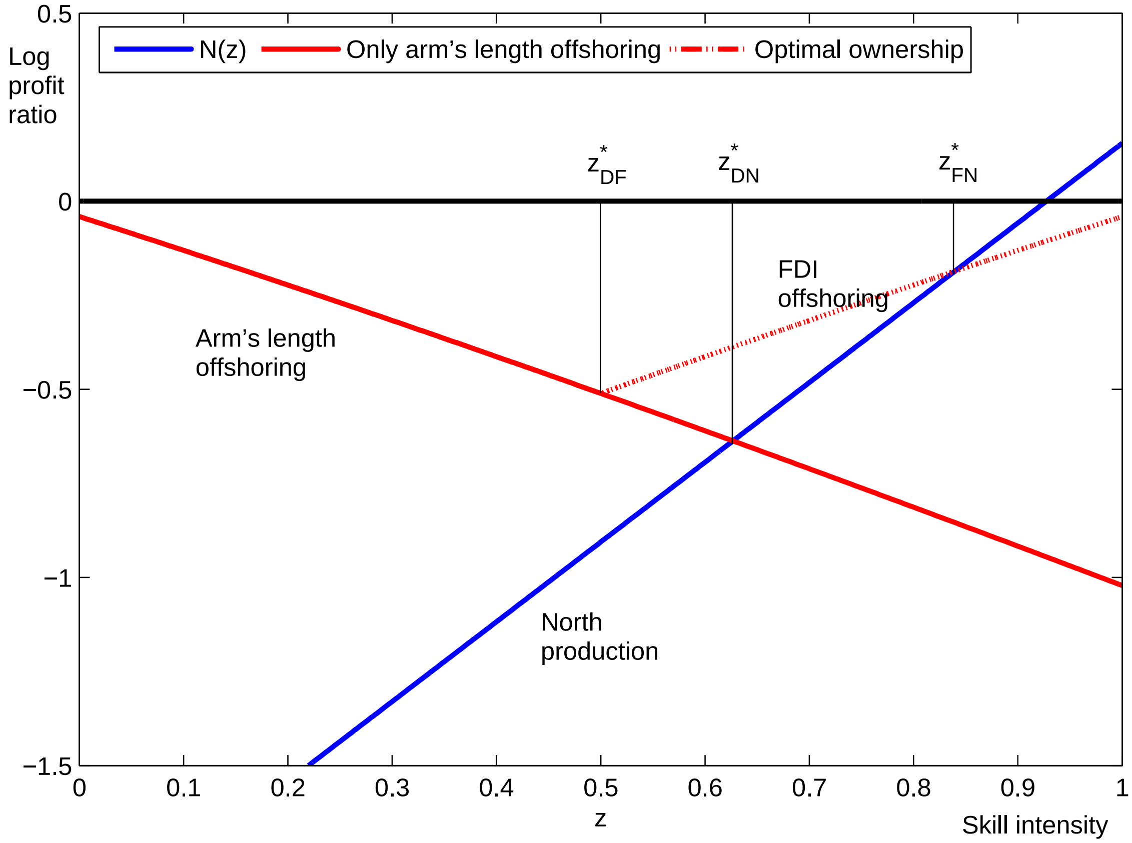
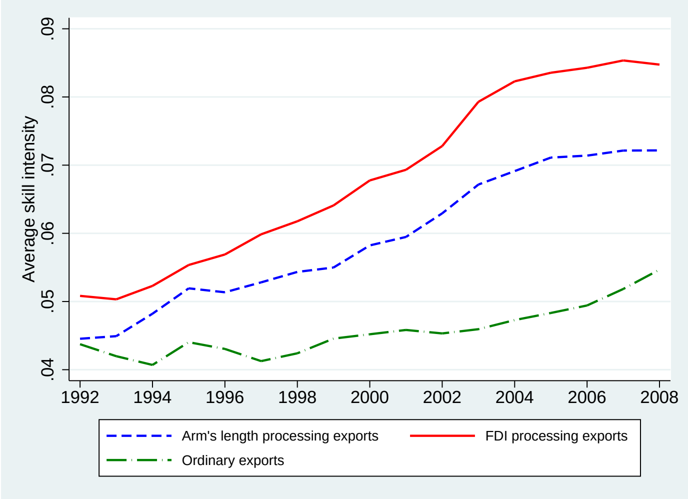
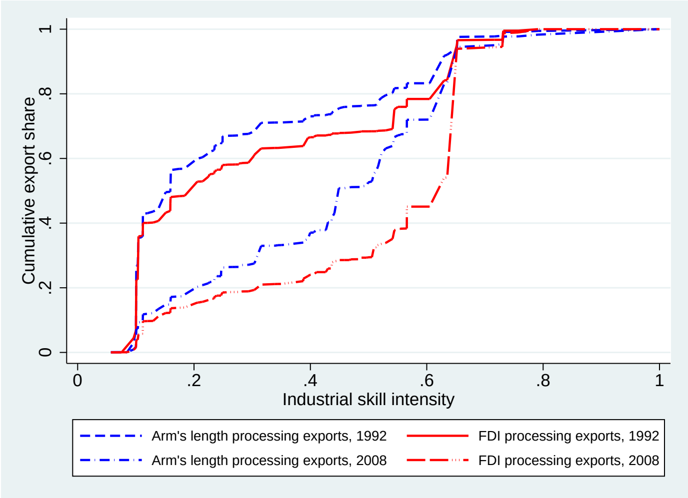


Figure 4: Ownership Liberalization, Offshoring, and Skill Intensity of Intermediate Goods



(a) Average Skill Intensity



(b) Skill Upgrading

Figure 5: Skill Content of Processing Exports

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 a continuous and differentiable function, we only need to show $\frac{\partial^2 S(z,\beta)}{\partial z \partial \beta} > 0$ for supermodularity. 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. Therefore, 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. Therefore, we only need to show that the inequality holds for $z = 0$, which is

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

These two inequalities are essentially the same if we redefine $\hat{\beta} = 1 - \beta$ for the second one. Thus, we only need to prove the inequality for $\beta \in [1/2, 1]$ by proving it in two cases where $\alpha < 2/3$ and $\alpha \geq 2/3$. For $\alpha < 2/3$, we 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 the convexity property of functions. Given that $g(\beta) = (1-\alpha\beta)^2$ is a convex function on the compact interval $[1/2, 1]$, we have

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

In the next step, we show that $S(z,\beta)$ 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

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

Given that $S(z,\beta)$ is continuous and strictly concave on 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, according to the Topkis's theorem, the supermodularity implies $\beta^*(z)$ increases in z. We show this in our paper by using the implicit function theorem. The first order condition for β is $S_\beta(\beta^*(z),z)=0$ for an inner solution. By 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 solutions, we have $\beta^*(0)=0$ and $\beta^*(1)=1$, thus 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 prove this lemma, 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 $\beta > 1/2$, $\frac{\partial S(z,\beta)}{\partial z} > 0$, $S(z=0,\beta) < S(z=0,1/2) = S(z=1,1/2) < S(z=1,\beta) \leqslant 0$. Given that $\beta^F > 1/2$, the log profit ratio of foreign-owned firms increases in z.

(c) For $\beta < 1/2$, $\frac{\partial S(z,\beta)}{\partial z} < 0$, $S(z=1,\beta<1/2) < S(z=1,1/2) = S(z=0,1/2) < S(z=0,\beta<1/2) \leqslant 0$. Given that $\beta^D < 1/2$, 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), given that $S(z,\beta)$ 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, given that $f(x) = \ln x + \frac{1-\alpha}{\alpha}[\ln(1-\alpha x) - ln(1-\alpha)]$ increases in x if $x \in (0,1)$, $f(x) \leq 0$ 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 $S(z = 1, \beta) = \ln \beta + \frac{1-\alpha}{\alpha}[\ln(1-\alpha\beta) - ln(1-\alpha)] \leq 0$. $S(z = 0, \beta)$ decreases in, while β and $S(z = 1, \beta)$ increases in β. Based on these properties, corollaries (b) and (c) both hold. Given that $S(z, \beta^F)$ increases in z and $S(z, \beta^D)$ decreases in z, and $S(z = 0, \beta^F) < S(z = 0, \beta^D)$ and $S(z = 1, \beta^F) > S(z = 1, \beta^D)$, two curves have one single 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, the cutoff z^*_{DF} also does not change as the offshoring cost varies.

C Proof of Proposition 1

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 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, while the 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

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

Given that $r(z,\beta)$ is non-increasing in z, we show $r(z,\beta) \leq r(0,\beta) = \ln(\frac{t}{(1-\beta)\omega_l}(\frac{1-\alpha}{1-\alpha(1-\beta)})^{\frac{1-\alpha}{\alpha}})$. Since $r(0,\beta)$ is strictly increasing in β for $\beta > 0$, 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 $B(1,\beta,t) > 0$, $\lim_{z\to 0} B(\beta,z,t) < 0$. Therefore, 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 $B_\beta d\beta + B_z dz + B_t dt = 0$. Given $B_t > 0$ and $B_z > 0$, $d\beta = 0$, we have $\frac{dz^*(t,\beta)}{dt} = -\frac{B_t}{B_z} > 0$. Given that $\beta^D < \beta^F$, 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, that is, $\pi(z) = \pi^N(z)$ for any $z > \max\{z^*_{DN}(t), z^*_{FN}(t)\}$. Moreover, the order of $z^*_{FN}(t), z^*_{DN}(t)$ must be one of the following cases: (1) $z^*_{FN}(t) > z^*_{DN}(t)$; (2) $z^*_{FN}(t) = z^*_{DN}(t)$; and (3) $z^*_{DN}(t) > z^*_{FN}(t)$. In the first case, three production modes coexist, while in the second and third case, the North foreign ownership ($O = F$) will not be optimal for any product z. The first case also implies that $z^*_{FN}(t) > z^*_{DF}$, as $z^*_{FN}(t) \leq z^*_{DF}$ would suggest $z^*_{DN}(t) \geq z^*_{FN}(t)$, which contradicts to the inequality in the first case. Thus, in the case where 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 those products offshored to the South, the more skill-intensive goods are through FDI offshoring ($z^*_{FN}(t) > z > z^*_{DF}$), while the less skill-intensive ones 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 three 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 the 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 total offshoring is given by

$$RS^F(t) = \frac{\int\limits_{z^*_{JF}}^{z^*_{FN}(t)} R(z,\beta^F)dz}{\int\limits_0^{z^*_{DF}} R(z,\beta^D)dz + \int\limits_{z^*_{DF}}^{z^*_{FN}(t)} R(z,\beta^F)dz} = \frac{\int\limits_{z^*_{JF}}^{z^*_{FN}(t)} \tilde{R}(z,\beta^F)dz}{\int\limits_0^{z^*_{DF}} \tilde{R}(z,\beta^D)dz + \int\limits_{z^*_{DF}}^{z^*_{FN}(t)} \tilde{R}(z,\beta^F)dz}$$

where $\widetilde{R}(z,\beta) = R(z,\beta)/(\frac{1}{t})^{\alpha/(1-\alpha)}$ is not dependent on offshoring cost t. The offshoring cost t affects the revenue share of foreign firms only through the extensive margin ($z^*_{FN}(t)$). The share of foreign firms increases along with $z^*_{FN}(t)$ which in turns increases as the offshoring cost t decreases. Thus, a reduction in offshoring cost increases FDI offshoring.

E Proof of Proposition 4

(1). The proof is straightforward for the case where only arm's length offshoring is possible. We provide the following 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 extensive margin mechanism of offshoring increasing skill demand is essentially the same as the mechanism of Feenstra and Hanson (1996), but note that the ownership structure amplifies the impact of the extensive margin of offshoring on the skill demand. The term in the bracket of the numerator can be decomposed as follows: $[h(\overline{z},\beta^F)/l(\overline{z},\beta^F) - h(z,\beta^O)/l(z,\beta^O)] = [\frac{h(\overline{z},\beta^F)}{l(\overline{z},\beta^F)} - \frac{h(\overline{z},\beta^O)}{l(\overline{z},\beta^O)}] + [\frac{h(\overline{z},\beta^O)}{l(\overline{z},\beta^O)} - \frac{h(z,\beta^O)}{l(z,\beta^O)}]$. 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 show

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

Each term in the three brackets can be shown to non-negative given $\alpha \leq 1/2$. The first one is

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

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

Also the term in the second bracket of the equation (E.1) is positive because

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

The term in the third bracket of the equation (E.1) is also 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 $z \in [0,1]$.

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

Given 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 $l(z,\beta^D) \geqslant l(z,\beta^F)$, that is,

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

Thus, we have $D_1 > D_0$, that is, ownership liberalization on MNCs increases the aggregate relative demand for skilled workers. The term in the second bracket of the equation (E.1) 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 the third bracket of the equation (E.1) 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 Data and Empirical Analysis

F.1 Concordance

We first aggregate the product level trade data at Harmonized system (HS) 6 digits to 4 digits ISIC rev.3, based on the concordance between ISIC rev.3 (4 digits) and HS (6 digits for various versions) provided by the World Integrated Trade Solution (WITS). Up confining the analysis to manufacturing sector, we cover 113 out of 127 groups of ISIC rev.3.

To use the skill intensity measure from the 1995 Chinese National Industry Census, which is based on Chinese Standard Industrial Classification 1994 (CSIC1994 at 3 digits), we construct a concordance for manufacturing between CSIC1994 (172 groups at 3 digits) and ISIC rev.3 (127 groups at 4 digits) through CSIC2002, as NBS provides the concordance between CSIC1994 and CSIC2002 at 4 digits, as well as the concordance between CSIC2002 and ISIC rev.3 at 4 digits. Our empirical analysis on the skill content of offshoring in section (4.1) remains robust if we use the alternative measure of industrial skill intensity from the 2004 Chinese National Economic Census.

F.2 Augmented Mincer Wage Regression

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

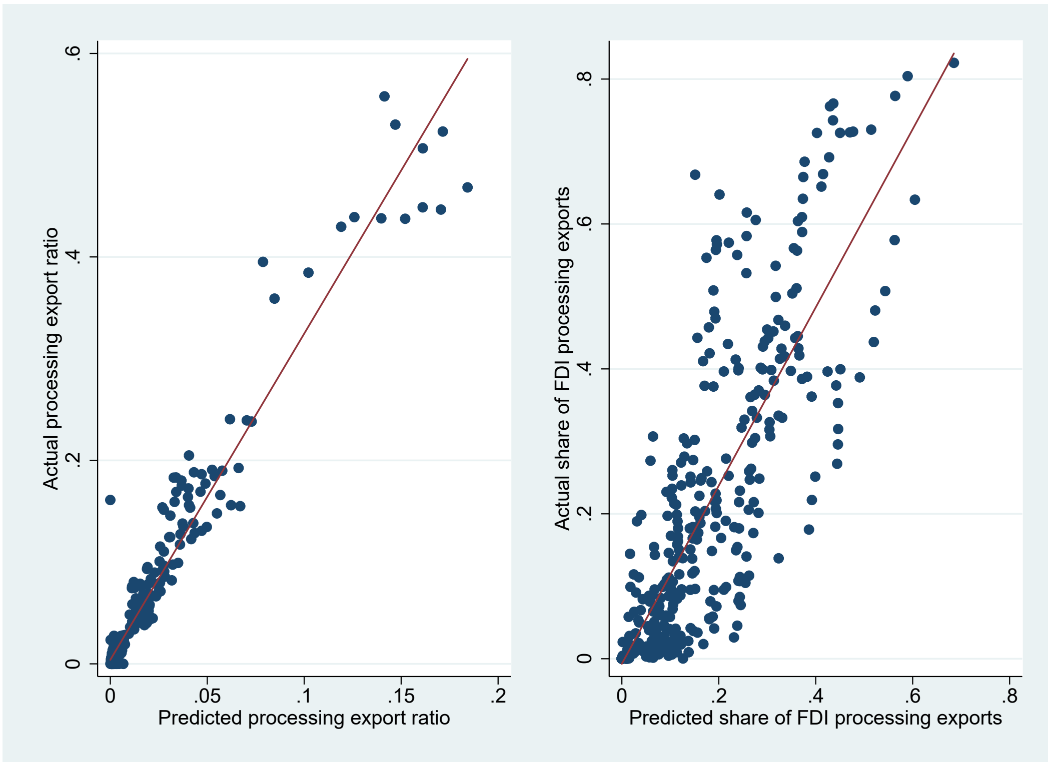


Figure F.1: Scatter Plot for First Stage Regression

Table F.1: Years of Education and Schooling Returns in China's Manufacturing Sector

	OLS		IV
	(1)	(2)	(3)
Schooling years	0.063***	0.040***	0.040***
	(0.002)	(0.005)	(0.003)
Interaction terms of schooling years			
Schooling years $\times$ Processing exports ratio		0.040**	0.050**
		(0.018)	(0.019)
Schooling years $\times$ Share of FDI processing exports		0.072***	0.073***
		(0.007)	(0.007)
Schooling years $\times$ Ordinary exports ratio		-0.110**	-0.161***
		(0.047)	(0.024)
Schooling years $\times$ R&D ratio		0.338*	0.574***
		(0.205)	(0.076)
Schooling years $\times K/Y$		0.006	0.007***
		(0.004)	(0.002)
Individual characteristics			
Experience	0.048***	0.048***	0.046***
	(0.001)	(0.001)	(0.001)
Experience square	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)
Sex	-0.195***	-0.194***	-0.200***
	(0.006)	(0.006)	(0.003)
Stated owned sector	0.176***	0.178***	0.176***
	(0.010)	(0.010)	(0.004)
Province-year FE	YES	YES	YES
First stage F-stat			> 221.03
Observations	156,658	155,905	143,010
R-squared	0.373	0.377	0.320

Note: The dependent variable is log (annual wage income). The province-year cluster robust standard errors are enclosed in parentheses for columns (1) and (2). *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

[a] Column (3) is estimated by GMM, where we use the constructed processing exports ratio and the share of FDI processing exports as instruments. The bootstrapped standard errors are enclosed in parentheses.

F.3 Provincial variables

Table F.2: Variable Description

Variable	Definition	Source
R&D ratio	R&D expenditure/nominal GDP	China Statistical Yearbook on Science and Technology, 1993-2009.
Capital-output ratio	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 - court cost	Word Bank Doing Business Survey
Infrastructure	Log (the total length of highways and railroads in kilometers per land area in square kilometers)	China Compendium of Statistics 1949-2008
National policy zones	The number of national policy zones	China Development Zone Review Announcement Catalogue, NDRC, 2007.
Skill endowment	The share of population aged above 5 with college degrees	Annual Population Survey, published in the China Population Statistics Yearbook, 1993-2009.

Table F.3: Summary Statistics of Individual and Provincial Variables

Panel A: Individual 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	435	0.05	0.09	0.00	0.56
Share of FDI processing exports	435	0.19	0.21	0.00	0.82
Ratio of ordinary exports to industrial output	435	0.07	0.06	0.01	0.61
R&D/Y	435	0.01	0.01	0.00	0.09
Capital-output ratio	420	1.44	0.43	0.67	2.78
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	0.00	27.00
Skill endowment (Share of persons with college degree in population aged above 5)	435	0.04	0.04	0.00	0.29