

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

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Abstract

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.

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

JEL classification: F16, J31, D23

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 are 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-

¹See 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.

²For instance, Feenstra and Hanson (1997, 1999), Hsieh and Woo (2005), and Zhu and Trefler (2005) find empirical evidence that offshoring increased the skill premia in both developed and developing countries. Ottaviano et al. (2013) study the differential roles of offshoring and immigration on native employment in the U.S. 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 paper seeks to answer. What policies and institutions can affect the composition of FDI and arm's length offshoring in the South? How

³According 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.

⁴FDI 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

⁵Other 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.

This study also contributes to the burgeoning literature on the effect of globalization on income inequality in developing countries.⁶ In the context of China, Han et al. (2012) found that trade liberalization upon China's WTO accession increases within-region wage inequality by raising returns to education in urban China based on CUHS data from five provinces. By developing a quantitative model that incorporates international and intra-national trade as well as migration costs in China, Fan (2019) showed that the gains from trade is greater for skilled workers than unskilled workers. Li (2018) found that the skill content of Chinese exports influence human capital accumulation based on an analysis of population census data. Although these studies shed light on the effect of trade liberal-

⁶See Goldberg and Pavcnik (2007) for a comprehensive review on the distributional effect of globalization in developing countries.

ization on income distribution, the underlying mechanisms have yet to be fully explored. By contrast, this paper highlights the role of FDI offshoring as an important channel in raising the skill premium in China. This study is also the first to estimate the Mincer wage regressions in the context of international trade using China's national urban household sample covering a long period from 1992 to 2006.

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

2 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, which we denote by h and l , respectively. Supply of labor is fixed and inelastic in two countries, and they are mobile within country but not across the border. 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. The world has one final good Y for consumption in both countries. The final good is free traded, and produced with a continuum of differentiated intermediate products. We assume that the North produces both the final good Y and intermediate products, while the South only produces intermediate products.

The final good is assumed to be assembled costlessly over a continuum of differentiated intermediate products indexed by $z \in [0, 1]$ with a constant-elasticity-of-substitution form in the North, i.e., $Y = [\int_0^1 y(z)^\alpha dz]^{1/\alpha}$. These goods are substitutes, implying $0 < \alpha < 1$ and the elasticity of substitution between any two products of $\sigma = 1/(1 - \alpha) > 1$. Thus, the demand for each product z is given by $y(z) = \lambda p(z)^{-1/(1-\alpha)}$ where $y(z)$ and $p(z)$ denote quantity and price, respectively. Moreover, λ measures the aggregate demand for the differentiated products under the assumption that these products are freely shipped without costs.

2.2 Intermediate Products

For any differentiated intermediate product z , a Northern innovator carries out R&D in the North and obtains the technology (blueprint) to produce the high-tech input. The innovator needs to find a low-tech input supplier in the North or South to manufacture the product. In other words, the innovation and product manufacturing are fragmentable.⁷

The manufacturing of any intermediate product z requires high and low-tech inputs, denoted as x_h and x_l respectively. More specifically, the production of the intermediate product 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 $0 \leq z \leq 1$. Thus, intermediate products are produced with different technologies, and they are ranked by

⁷Our focus is the effect of offshoring on the labor market in the South. Thus, we avoid complicated modeling for the R&D decisions of the Northern innovator. For simplicity, we assume that the Northern innovator pays a fixed cost f for R&D, which is below a threshold, such that each product will be produced in equilibrium. We further normalize the fixed cost to zero in subsequent analyses, which does not affect our model predictions.

the intensity of high-tech inputs. To simplify the exposition, we assume that one unit of high-tech (low-tech) input requires one unit of high-skilled labor h (low-skilled l).⁸ We also assume that the manufacturing of each intermediate product z is not fragmentable; that is, the production of its two inputs takes place at the same location.⁹

For an intermediate good z , only the Northern innovator has the technology (blueprint) for producing the high-tech input; however, she needs to find a low-tech input supplier in the North or the South. The investments by the two parties are assumed to be relation-specific. The contract environment is a key difference between the North and the South. If the Northern innovator chooses to produce domestically, the contract is assumed to be complete. However, if the innovator offshores to produce the product, then she faces incomplete contracts because of poor legal environments in the South. With incomplete contracts, the quality of the inputs x_h and x_l is not verifiable by a third party. Therefore, on the basis of the literature of incomplete contracts (Grossman and Hart, 1986; Antràs, 2005), we assume that the Northern innovator chooses the ownership structure (O) of joint production. She can either set up a foreign affiliate ($O = F$), or outsource production to a Southern supplier ($O = D$). The supplier needs to pay the innovator a lump-sum transfer T as a participation fee because many suppliers compete for the job in the South. This fee results in the Southern supplier to break-even. Moreover, the Northern innovator needs to pay an offshoring cost proportional to the output of z . Thus, for one unit of z , the offshoring cost is $t - 1$ unit with $t \geq 1$.

The above specifications on intermediate goods production are built on Antràs (2005). However, they have two noticeable differences because our research question is different from his study on product cycle. First, we extend his model by including two types of

⁸We can relax this assumption to accommodate differences in labor productivity across countries.

⁹Note that Feenstra and Hanson (1996, 1997) assumed non-fragmentable production of each intermediate good to evaluate the effect of offshoring on the skill premium. This assumption reflects the reality that a processing firm in the South must hire high-skilled labor, such as managers and engineers, even if a low-tech intensive product z is offshored to the South. The firm still requires production management, training, quality control, and so on. This assumption allows various outcomes for offshoring and demand for skills in the South.

labor to examine the effect of offshoring on the demand for skill in the South. Second, different from his model where only the low-tech inputs are offshorable, we assume that for a given intermediate input z , the production of its two inputs takes place at the same location, whereas different intermediate products z are produced either in the North or the South depending on their high-tech input intensities. These specifications allow for various outcomes to study the effect of offshoring on skill demand and wage inequality in the South.

Now 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 chooses to offshore, then the innovator and the Southern supplier will engage in symmetric Nash bargaining over the surplus after production from their relation-specific investments because of incomplete contracts in the South. Symmetric Nash bargaining implies that the innovator and the supplier each obtains half of the surplus, if the contract does not hold. Therefore, the ex-post revenue share of the Northern innovator β is determined by the bargaining share and outside options associated the ownership structure. More specifically, if the innovator owns the firm ($O = F$), then it can fire the low-tech supplier in case they do not achieve an agreement with bargaining. Although the supplier is left with nothing, the innovator can still obtain δ fraction of the output, where $0 < \delta < 1$, and thereby generate a revenue of $\delta^\alpha R$. The quasi-rent of this relationship is $(1 - \delta^\alpha)R$. Bargaining leaves each party with its outside option plus one-half of the quasi-rent. Hence, the ex post revenue share of the 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 of revenue is $\beta^D = \frac{1}{2}(1 - \delta^\alpha)$. Clearly, we have $0 < \beta^D < 1/2 < \beta^F < 1$.¹⁰

Since the delivery of the inputs x_h and x_l are not contractible ex ante, the two parties choose their quantities to maximize their own payoffs. The supplier sets l^S to maximize $(1 - \beta)R(z) - w^S l^S$, and the Northern 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. Moreover, before their relationship has been formed, the Northern innovator also offers the contract by requesting a participation fee T from the suppliers whose outside option is zero. Thus, the Northern innovator chooses T to make the low-tech supplier break even and obtains the *ex ante* profit as follows:

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

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

2.3 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

¹⁰The previous version of the paper shows that the qualitative results of the model continue to hold in the presence of joint ventures with $\beta = 1/2$, which indicates that each party has the veto power.

Northern production relative to the Southern production:

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

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 a 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 as 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 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:

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

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) $\omega_l > \frac{t}{1-\beta^F} \left[\frac{1-\alpha}{1-\alpha(1-\beta^F)} \right]^{\frac{1-\alpha}{\alpha}}$.

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.¹¹ Figure 2 plots the curves of log profit ratios $N(z)$, $S(z, \beta^D)$, and $S(z, \beta^F)$, while Appendix A-C discuss the properties of these curves in detail. The optimal choices for Northern innovators are the upper contour of the three log profit ratios. Based on this assumption, we present our main proposition as follows:

¹¹This assumption imposes an upper bound for β^F , that is, $\beta^F < \tilde{\beta} \equiv f^{-1}(\omega_l/t)$, where $f(\beta) = \frac{1}{(1-\beta)} \left[\frac{1-\alpha}{1-\alpha(1-\beta)} \right]^{\frac{1-\alpha}{\alpha}}$. The intuition for this upper bound for the Northern innovator's revenue share is that the South supplier will have little incentive to invest in low-tech input if his revenue share $(1 - \beta)$ is close to 0. $f(\beta)$ is an increasing function. Therefore, if β^F satisfies this inequality, then this inequality also holds for β^D . Given that the upper bound depends on ω_l and t , this assumption is more likely to hold if the offshoring cost is low, given ω_l .

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).¹² 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 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 fewer 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

¹²This 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.

the South.

2.4 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 cutoff is z_{DN}^* , that is, the Northern innovator only outsources limited low skill-intensive products through arm's 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.¹³ 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.

¹³FDI offshoring is an optimal choice for skill-intensive products when $z_{DN}^* > z_{DF}^*$, as shown in Figure 2. It would be ideal to pin down from the model the parameter conditions for $z_{DN}^* > z_{DF}^*$. Although we show the existence of z_{DN}^* and z_{DF}^* in Appendices B and C, respectively, their close-form solutions are unavailable. Therefore, we cannot derive the exact parameter ranges for $z_{DN}^* > z_{DF}^*$. However, Appendix B shows that z_{DF}^* is independent of offshoring cost t , whereas Appendix C shows that z_{DN}^* increases with the decrease of offshoring cost t , that is, more products are offshored to the South when offshoring cost declines. Hence, it is more likely that $z_{DN}^* > z_{DF}^*$, when the offshoring cost is low.

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.¹⁴ 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 skill-intensive products to the South through FDI offshoring, thereby increasing the share of FDI offshoring.*

2.5 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.

¹⁴These 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.

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:

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

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:

$$\ln W(C, \Phi) = \alpha_0 + \alpha_1 C + \alpha_2' \Phi + \varepsilon, \quad (6)$$

where $W(C, \Phi)$ is the individual wage income at schooling level C and personal characteristics Φ . 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. Φ 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 $E(\varepsilon|C, \Phi) = 0$.

The coefficient of the dummy variable of schooling represents college wage premium in percentage terms, that is, $\alpha_1 = E(\ln W|C = 1, \Phi) - E(\ln W|C = 0, \Phi) = \ln(q/w)$, 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 $\ln(q/w) = \ln D^{-1}(t, \Psi)$, 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:

$$\ln W(C, \Phi, t, \Psi) = \alpha_0 + \alpha_1(t, \Psi)C + \alpha'_2\Phi + \varepsilon. \quad (7)$$

3.2 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:

$$\ln R^O = \ln R^O(t, \Psi), \quad (8)$$

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:

$$\ln W(C, \Phi, t, \Psi) = \alpha_0 + (\alpha_{10} + \alpha_{11}R + \alpha_{12}RS^F) \times C + \alpha'_2 \Phi + \epsilon. \quad (9)$$

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 insufficient 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 based on cross-regional variations. Recent studies show a massive migration as response to trade liberalization and reductions in migration costs (Fan, 2019; Facchini et al., 2019; Zi, 2019). Despite the massive migrations across regions, the large spatial disparity in wage level and skill premia remains. 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. These regional wage ratios in China have not declined but instead increased slightly to 2.96 and 3.01 in 2006, indicating that migration costs cross regions are still substantial (Tombe and Zhu, 2015). Given the persistent regional wage gaps and insufficient labor mobility across Chinese provinces, we explore regional variations to identify the impact of offshoring on labor market outcomes. In the sensitivity analysis, we will explicitly discuss the implications of migration on skill premium, and directly control for the reduction in migration costs due to the reform on Chinese Hukou system in our regression analysis.

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 was 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 the 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 2007.¹⁵ In encouraged industries, foreign investors were given more free-

¹⁵Lu et al. (2017) also uses CGFII to document China's FDI regulation policy changes at industrial level between 1997 and 2002 to identify the effect of FDI spillover. Our analysis is more comprehensive as we include all versions of CGFIIs published between 1995-2007.

dom 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.¹⁶

We use two proxies to measure the reduction in offshoring cost. The first measure is the cumulative number of national policy zones.¹⁷ Recent studies such as Wang (2013) show that the policy zones in China promote foreign investment and processing trade by reducing offshoring costs, and Khandelwal and Teachout (2016) also show that firms in policy zones have better access to infrastructure and customs clearance in Bangladesh and India. 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.

¹⁶See 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.

¹⁷China 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. 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 (NDRRC, 2007).

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 exports as a proxy for offshoring because processing activities involve foreign firms that either work with their own affiliates or contract with local firms to assemble imported inputs for exporting to foreign markets. This definition corresponds closely to the specifications of our model. Moreover, the existing literature also uses processing exports to measure offshoring in the context of China (e.g., Feenstra and Hanson (2005) and Fernandes and Tang (2012)).

The Chinese government implemented favorable regulations towards processing trade, as opposed to ordinary trade, in the period of analysis. Those policies aimed to motivate foreign firms to shift their offshore production to China and to encourage domestic firms to process and assemble products for foreign clients. As part of the regulations, the government lowered the costs of importing raw materials and intermediate inputs with free import duties for processing exports, given that average Chinese tariffs on imports were still about 8% in 2008 after China's accession into the WTO. Moreover, processing firms received exemptions from value-added tax under the condition that they must export the processed products. These special arrangements provided strong financial incentives for foreign firms to offshore their production to China for processing and assembly, when their markets were at home or in other countries outside of China. The share of foreign-owned and joint ventures in processing exports increased from 39% in 1992 to 85% in 2008, and approximately 90% of processing exports during this period were sold to high-income countries. Indeed, firms in China could choose ordinary or processing trade; however, most firms involved in global production sharing selected processing trade given the favorable policies towards offshoring between 1992 and 2008.

Following the literature of vertical integration in the context of China such as Spencer

(2005), Fernandes and Tang (2012), and Luck (2017), we use processing export by wholly foreign-owned firms to proxy 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.¹⁸

Table 1 presents the summary statistics of China's processing exports. The data reveals that processing exports play a major role in China's international trade and account for around 56% of the country's total exports from 1992 to 2008. The share of FDI processing exports have increased from 10% in 1992 to 64% in 2008, and the shares of FDI processing exports in high-skilled industries exceeded the shares of FDI processing exports in low-skilled 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 consists 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.

¹⁸Our 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 all of China's trade partners as North countries. All of our major empirical results hold for both samples.

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.¹⁹ 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).²⁰ 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.²¹ 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 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

¹⁹The average skill intensity for the firm ownership type O in year t is defined as $\bar{z}_t^O = \sum_i z_i (R_{i,t}^O / \sum_i R_{i,t}^O) = \sum_i z_i * RS_{i,t}^O$, 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 .

²⁰Appendix F2 shows more details on data measurement and concordance.

²¹The empirical distribution $\hat{G}^O(z)$ is constructed as follows: $\hat{G}_t^O(z) = \sum_i I(z_i \leq z) * RS_{i,t}^O$, where $I(\cdot)$ is the indicator function.

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% 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% 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, $skshr_t^F = \sum_i z_i R_{i,t}^F / \sum_i z_i R_{i,t} = (\tilde{z}^F / \tilde{z})(\sum_i R_{i,t}^F / \sum_i R_{i,t}) =$

$Z^F * RS_t^F$, where $Z^F = \tilde{z}^F / \tilde{z}$ 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% to approximately 70% of the total skill content in processing exports. Therefore, FDI is mainly responsible for the increase of the skill content in processing exports.²²

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

$$\begin{aligned} \ln(R_{oijt}) = & \theta_0 + \theta_1 F_{oijt} + \rho_1 EP_{it} + \rho_2 RP_{it} + \rho_3 Cost_{jt} \\ & + (\gamma_1 EP_{it} + \gamma_2 RP_{it} + \gamma_3 Cost_{jt}) \times F_{oijt} + \boldsymbol{\theta}'_2 \mathbf{X} + \xi_i + \xi_j + \xi_t + \epsilon_{oijt} \end{aligned} \quad (10)$$

²²Data 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.

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 X , we follow Romalis (2004) by interacting factor endowment variables, physical and human capital, with industry-specific factor intensity.²³ 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.²⁴ 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,

²³Industry-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.

²⁴Industry-specific contract intensity is proxied by the inputs share of the relation-specific intermediates based on the Chinese input-output table. We are very grateful to Hong Ma for sharing the Nunn 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.

all variables, except for the indicator variables, are de-measured 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. Accordingly, we also adopt province-year cluster robust standard errors to control for sample dependence.

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 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 inten-

sities 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.²⁵ 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%, while the implementation of restriction policy reduces FDI exports by 43.5%. Similarly, ownership policies do not significantly affect arm's length processing exports. Under this specification, a 1% increase in highway and railway density increases FDI processing exports by 0.21% relative to arm's length processing. Adding one more national policy zone in a province results in an 8% increase in FDI processing exports relative to arm's length processing.²⁶ These estimates capture the average effects of policy and offshoring cost on

²⁵Contract environments could be endogenous to trade, which would affect the estimates of the regression. On the basis of Feenstra et al. (2013) and Sheng and Yang (2016), we use former colonial ties with countries, such as Britain, France, Russia, Germany, or Japan, or combination of multiple powers and provincial population in 1953 as instrumental variables for contract environments. The coefficient of contract environment and industry-specific contract intensity decline slightly from the OLS estimate of 0.141 to an IV estimate of 0.123, whereas other coefficients barely change.

²⁶We include an interaction of $EP \times Policy\ zones$ and a triple interaction of $F \times EP \times Policy\ zones$ to explore a potential complementary relationship between national policy zones and encouragement policy. The result shows a positive and statistically significant coefficient for the triple interaction, which indicates a complementary effect of national policy zones and encouragement policy for FDI processing exports. The coefficient for the simple interaction term is negative and statistically significant, which suggests that the national policy zones favor FDI processing exports to arm's length processing exports for industries with

processing exports across all industries.²⁷

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.²⁸ Moreover, infrastructure and policy zones strongly enhance FDI processing exports in high-skill intensive industries. These findings are consistent with the model predictions.²⁹

Finally, we conduct several robustness checks on the determinants of processing trade. First, we control for a number of concurrent policy changes during China's ownership liberalization on foreign investment, which can have significant effects on Chinese exports. In the regression, we include China's trade partners' import weighted tariffs on Chinese exports at the ISIC four-digit level and the reduction in trade policy uncertainty, as measured by weighted normal trade relation (NTR) tariff gap from Pierce and Schott (2016). Moreover, we also remove from the sample of those industries that are affected by the expiration of the Multi-Fiber Arrangement based on Khandelwal et al. (2013). As shown in Table F.1 in the Appendix, our baseline findings are not sensitive to these extra controls. The results show that reduced external tariffs increase China's exports. Moreover,

encouraged policy. The other estimated coefficients are similar to our baseline results reported in Column 3 of Table 3.

²⁷The 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 Teneyro (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.

²⁸The coefficients for key variables, including encouragement and restriction policies, their interactions with the FDI indicator, and the interaction term of national policy zones with the FDI indicator, significantly differ from each other between the two sub-samples.

²⁹Interestingly, 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.

lower trade policy uncertainty in the U.S. has a positive yet insignificant effect on Chinese exports to high-income countries, which possibly indicate that reduced uncertainty only affects Chinese exports to the U.S.

Second, we control for industry-specific linear trends that can help identify the effects of ownership liberalization policies on foreign investment. If the encouragement policies covered those industries with higher rates of growth prior to the WTO accession, then the estimated effects of ownership liberalization on processing exports may well capture trend differences across industries, which result in an upward bias. Table F.1 shows that the baseline results are not sensitive to the inclusion of industry-specific linear trends.

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:

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

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_{jt}^F), and Φ 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_{jt}^F 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 $V_{jt} \times C_{mjt}$. 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 $\{R_{jt}, RS_{jt}^F\}$ 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 choose to offshore or establish their foreign affiliates in regions with abundant high-skill and high-quality workers, the locational selection would imply positive biases in the estimates for the interaction terms. To mitigate poten-

tial endogeneity, we adopt a two-stage IV approach (Angrist and Pischke, 2008).³⁰ First, we construct the predicted values of processing export-to-output ratio \widehat{R}_{jt} and the share of FDI processing exports \widehat{RS}_{jt}^F from the determination of processing exports as follows:

$$\widehat{R}_{jt} = \sum_{i,o} \exp(\widehat{\ln R_{oijt}}) / ind_output_{jt}$$

$$\widehat{RS}_{jt}^F = \sum_{i,o=F} \exp(\widehat{\ln R_{oijt}}) / \sum_{i,o} \exp(\widehat{\ln R_{oijt}})$$

where $\widehat{\ln R_{oijt}}$ is predicted value 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_{jt}^F in the augmented Mincer regression.³¹ Figure F.1 in the Appendix presents scatter plots of actual and predicted values of processing export ratio and the share of FDI processing export, which show close correlations.

These predicted values constitute legitimate instruments for the wage regression because key determinants of processing exports by type, such as ownership liberalization policies, national policy zones, and infrastructure, are plausibly exogenous to labor force characteristics, including the relative wage of skilled versus unskilled workers. This IV approach would be questionable if the above policy initiatives targeted high skill premium growth in selected provinces, or national policy zones and infrastructure affected skill premium growth other than the channel of FDI processing exports.

Many policy zones and infrastructure projects were already built before China's accession to WTO in 2001, when nationwide ownership liberalization policies on foreign

³⁰This two-stage IV approach is necessary because the sample dimensions are different between the trade data and urban household survey data. The trade data in the first stage contains industry-level information that allows us to identify the effects of FDI ownership liberalization on processing exports. In comparison, the household data in the second stage do not contain industry-specific information but allow the analysis of schooling returns at individual level. Given that both data have regional information, the two-stage procedure allows us to use regional variations upon exposure to offshoring to identify the effects of processing exports on college premium in the Mincer regression.

³¹While 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.

investment were largely implemented. Thus, we can test whether policy zones and infrastructure projects targeted high skill premium growth based on information before China's accession to WTO. For this purpose, we compiled province-level data on cumulative policy zones and total lengths of railways and highways in 1992 and the subsequent changes in college premiums between 1992 and 2000 estimated from the urban household survey data. If the infrastructure projects and policy zones targeted subsequent growth of the college premium, we would observe increases in high skill premium for the subsequent period (1992–2000).

Our empirical analyses find no evidence of policy targeting on the growth of schooling returns. In the benchmark case, we regress the change in college premiums between 1992 and 2000 on accumulative policy zones and infrastructure in 1992 conditional on college premium in the initial year. As shown in Table F.2 in the Appendix, the estimated coefficients for the two policy variables are not statistically different from zero, which indicates no evidence of policy targeting. This benchmark result is robust to various specifications, including alternative measures of college premium (i.e., from the baseline Mincer regression to adding controls, such as gender, experience, and state-sector indicators) and controlling additional covariates, such as capital-output ratio, relative skill endowment, and real GDP per capita in 1992. This analysis also suggests that national policy zones and infrastructure did not affect the skill premium through other channels before China's WTO accession.

We take a different approach to validate the exogeneity of ownership liberalization policies, because college premium estimates are unavailable at the industry level. Instead, we provide direct and indirect evidence that trade liberalizations did not target labor market outcomes. First, the relaxation of FDI regulations was largely due to China's compliance with the agreement on TRIMs, a requirement for the country's accession into the WTO. In accordance with TRIMs, China enacted new laws and amended existing regulations regarding FDI inflows (Sheng and Yang, 2016; Lu et al., 2017). In 2002, the

government released an important document, "Provisions on Guiding the Orientation of Foreign Investment," which provided guidelines for encouragement and restriction policies on FDI. The encouragement policies covered a wide range of industries, including agriculture, energy, transportation, manufacturing, and raw materials. The restricted or prohibited industries included health, public safety, military facilities, culture, and entertainment, as well as industries that either have adverse effects on the environment or use traditional technologies of China. Direct targeting on the labor market outcomes was not observed.

Second, similar to our approach, Lu et al. (2017) also treated the liberalization of FDI regulations around 2001 as a plausibly exogenous event. Their regression analyses suggest that the industries under the encouraged policies are unrelated systematically to labor force characteristics, such as employment and average wage. Such evidence lends additional support for using ownership liberalization policies as instruments.

To address concern (b) of potential ability bias in the wage regression, we perform a series of sensitivity tests, including cohort analysis. We will explain later that our main findings are not sensitive to various controls for possible ability bias.

Table 4 presents the estimation results for the determinants of earnings by using the CUHS data from 1992 to 2006.³² Column (1) starts with the OLS estimates of the basic regression. The interaction terms of offshoring variables $\{R_{jt}, RS_{jt}^F\}$ 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 $\{\widehat{R}_{jt}, \widehat{RS}_{jt}^F\}$.

Several findings emerge from the basic specification. First, workers with college education earn a 35% wage premium relative to workers without college education. Second, the returns to experience for Chinese workers exhibit a typical concave profile, where one

³²See Table F.5 for the summary statistics of household characteristics and related provincial variables.

year of experience increases a worker's real wage by 4.8% at the beginning of their careers. Third, the average wage of female workers is 20.2% less than that of male workers, thereby indicating a significant gender earnings gap. Fourth, workers in the state sector earn a 19.5% 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.³³

The most important empirical findings on wage inequality are presented through the interaction terms of the college indicator with the two offshoring variables $\{R_{jt}, RS_{jt}^F\}$. Each of these coefficients reported in Columns (2)-(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 OLS regression, 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 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% in Column (1) to 22.1% 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. One percentage point increase in the ratio of or-

³³See Ge and Yang (2014) for a recent analysis of China's wage structure and the references cited therein.

dinary 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%, thereby contributing to nearly 50% ($25 \times 0.295 = 7.375$) 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% of the increase in the college premium.³⁴ 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.

³⁴Hale and Long (2012, chap. 4) 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.

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) of the rising college premium, respectively. Our results suggest that the contributions of R&D expenditure and capital-output ratios to skill premium are limited compared with the prominent role of FDI offshoring in explaining the rising skill premium in China's manufacturing sector from 2000 to 2006. We interpret this result in the context of the following factors. First, FDI and trade played a prominent role in the manufacturing sector, whereas domestic R&D expenditures may only have limited influence on the SBTC in manufacturing. Second, the shock of FDI inflows was particularly large immediately after China's WTO accession in 2001. China soon became the "world's factory," and foreign firms accounted for approximately one-third of its gross industrial output in 2006. Meanwhile, China became one of the largest exporters in the world, with foreign companies contributing 58% of its total exports. These FDI inflows in a short period appear to have a large effect on labor markets in China. Similarly, Feenstra and Hanson (1997) found that FDI growth in Mexico accounted for over 50% of the increase in the wage share of skilled labor in the late 1980s in regions where FDI was concentrated. Finally, FDI offshoring can also capture part of the SBTC because it is an important source of technology upgrading in developing countries (Acemoglu et al., 2015).

4.4 Sensitivity Analysis

Here we discuss the results of extensive robustness checks for the benchmark specification on college premium. First, recent studies suggest that trade liberalization in China triggered internal migration, which was facilitated by reduced migration costs resulting from household registration (Hukou) reforms (Fan, 2019; Facchini et al., 2019; Zi, 2019). To control for potential confounding effects of migration frictions on estimating the college premium, we include a Hukou reform index, a proxy for changing migration costs

across Chinese provinces, in the Augmented Mincer regression.³⁵ In principle, the inflow of skilled migrants increases the relative supply of skills, which reduces skill premium in the destination. However, educated migrants often work in skill-intensive industries and can generate agglomeration effects, which increase college premium in those provinces. Reductions in migration costs from Hukou reforms have similar offsetting effects on the skill premium in provinces because high-skilled workers are more mobile than the low-skilled ones. More specifically, we include an interaction term between changes in the Hukou reform index and the college dummy in the Mincer regression as sensitivity analysis. We find that all baseline results remain stable after controlling for migration costs. As shown in Column 1 in Table 5, the estimated coefficient for the interaction term indicates that Hukou reforms have a positive yet statistically insignificant effect on college premium. This result indicates a possible agglomeration effect of skilled workers on schooling returns.

Second, the estimation of schooling returns can be biased due 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, which are potential instruments for the college indicator, we focus instead on the birth cohort, that is, who was eligible for college education during the Cultural Revolution (CR; 1966-1976) as a robustness check. College entrance examinations were abolished during CR; thus, the selection of youth into college was politically oriented and independent of the innate abilities of the candidates for learning. Park et al. (2015) found that CR was an equalizer of educational access, and that the educational attainment of youth in cities became considerably less correlated with that of their parents compared with other cohorts before or after CR. To implement an approach with a limited

³⁵ Fan (2019) constructed this city-level index based on news articles, official documents, and government regulations on Hukou policies using keyword searches on two comprehensive databases. He found that the changes in Hukou reform index have significant effects on migration. This measure captures arguably exogenous changes in migration costs for individual migrants because policy requirements for Hukou is set at the city level.

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 4 for the two worker groups.

Columns 2 and 3 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. This gap in college premium between the two cohorts could reflect a possible upward bias associated with omitted ability and lower quality of education during CR. However, the estimates for the two key interaction terms of college with the ratio of processing exports and the share of FDI processing exports remain positive and statistically significant; moreover, their magnitudes of (0.348, 0.301) and (0.498, 0.256) for the two cohorts are not statistically different. These results indicate that the estimated effects of skill demand from offshoring are not sensitive to possible omitted ability or changes to education quality.

Third, 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 processing exports may not be gender neutral, we also estimate the earnings function by separating the male and female samples. The results in Columns 4 and 5 indicate that the college premium is larger among women (30.2%) compared with 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 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.

Fourth, we use years of schooling as the alternative 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.3. We also find the highly significant effects of SBTC on schooling returns and capital-skill complementarity, which is consistent with our benchmark results in Column 5 of Table 4.

Fifth, we use the processing exports to all trade partners of China instead of exports to only high-income countries as our alternative measure of offshoring. This alternative measure considers 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.³⁶ 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).

Sixth, foreign firms can offshore production to China through their affiliates or joint ventures. Thus far, empirical analysis has used processing exports by wholly-foreign-owned firms as FDI offshoring, whereas grouping processing exports by joint ventures and Chinese-owned firms as arm's length offshoring. We include an interaction term between the share of processing exports by joint ventures and the college indicator in the Mincer regression to examine whether foreign-owned firms and joint ventures played different roles in skill premium growth in China. The estimated coefficient is small and negative at -0.105 with 10% statistical significance, in contrast with the positive effect of FDI processing exports.³⁷ This result is consistent with the hypothesis that joint ventures are less skill-intensive than foreign-owned firms and that such ventures increase the relative demand for non-skilled labor.

³⁶The regression results for the trade equation (Equation 10) are also robust if we use processing exports to all destinations as the dependent variable.

³⁷In an earlier version of the paper, we analyzed three types of firm ownership in theory and by empirical analysis. Under the assumption of equal revenue shares for the two partners of a joint venture, the model predicts that goods offshored through FDI are more skill-intensive than those offshored through joint ventures and indigenous firms in the South. The intuition is straightforward, while empirical evidence also supports this finding. However, a serious drawback of incorporating three ownership types is the increased complexity of the model and the burden of presenting detailed empirical findings. Given this trade-off, we decided to pursue a cleaner approach by grouping together the joint ventures and Chinese firms in the model and the empirical analysis.

Lastly, Northern innovators can outsource part of their production to another foreign firm operating in China (e.g., a Taiwanese company). In the study, we process this type of outsourcing as FDI processing exports, which is arguably a misclassification. Unfortunately, the coding of the data does not permit us to pin down specific details of offshoring at different stages of the supply chain. In absence of ideal data, the existing literature on global vertical integration has used the same measure as ours (see Spencer (2005), Fernandes and Tang (2012), and Luck (2017) for offshoring to China). However, this subtle measurement issue may not affect our estimates for the effect of processing exports on college premium for two reasons. First, the skill content of the tasks that a Northern firm outsources to another foreign firm in China (e.g., the Taiwanese case) is likely to fall between FDI processing exports and arm's length processing exports, given that foreign firms in China are perceived to have better technology and management than typical Chinese firms. Second, as we have shown in Section 4.1, arm's length processing exports are less skill-intensive than FDI processing exports. Therefore, if low-skilled arm's length processing exports are misclassified as more-skilled FDI processing exports, then our estimated effects of FDI processing exports on college premium would be rather conservative.

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 was 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			
P-value	Two-sided test		One-sided test
	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			
	P-value	Two-sided test	One-sided test
		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*** (0.060)	-1.214*** (0.060)	-1.219*** (0.060)	-1.769*** (0.122)	-1.148*** (0.061)
Enc. policy	0.068 (0.073)	0.078 (0.072)	0.093 (0.073)	0.263** (0.112)	-0.095 (0.093)
Res. policy	-0.077 (0.059)	-0.056 (0.056)	-0.057 (0.055)	0.063 (0.066)	-0.383*** (0.089)
Natl. policy zones	0.025** (0.011)	0.019 (0.012)			
Infrastructure	0.278** (0.111)	0.319*** (0.111)			
FDI × Enc. policy	0.244*** (0.055)	0.244*** (0.055)	0.244*** (0.055)	0.751*** (0.115)	0.180*** (0.059)
FDI × Res. policy	-0.448*** (0.060)	-0.441*** (0.060)	-0.435*** (0.060)	-0.520*** (0.079)	-0.156** (0.076)
FDI × Natl. policy zones	0.078*** (0.009)	0.082*** (0.009)	0.080*** (0.009)	0.088*** (0.010)	0.075*** (0.009)
FDI × Infrastructure	0.205** (0.089)	0.186** (0.091)	0.209** (0.093)	0.301** (0.118)	0.191* (0.098)
Skill intensity × Skill endowment		0.857*** (0.081)	0.862*** (0.081)	0.491*** (0.102)	0.569* (0.293)
Capital intensity × Capital-output ratio		0.006** (0.003)	0.006** (0.003)	0.004 (0.004)	0.004 (0.003)
Contract intensity × Court efficiency		0.140*** (0.012)	0.141*** (0.012)	0.166*** (0.014)	0.152*** (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*** (0.009)	0.251*** (0.011)	0.214*** (0.031)	0.256*** (0.010)	0.221*** (0.022)
College indicator interaction terms					
College × Processing exports ratio		0.440*** (0.140)	0.492*** (0.145)	0.489*** (0.122)	0.534*** (0.132)
College × Share of FDI processing exports		0.315*** (0.043)	0.316*** (0.045)	0.284*** (0.050)	0.295*** (0.049)
College × Ordinary exports ratio			-0.202 (0.224)		-0.264* (0.137)
College × R&D ratio			0.904 (0.869)		1.548*** (0.475)
College × Capital-output ratio			0.029 (0.024)		0.025* (0.015)
Individual characteristics					
Experience	0.048*** (0.001)	0.048*** (0.001)	0.048*** (0.001)	0.047*** (0.001)	0.047*** (0.001)
Experience square	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Sex	-0.202*** (0.006)	-0.202*** (0.006)	-0.202*** (0.006)	-0.208*** (0.003)	-0.208*** (0.003)
State owned sector	0.195*** (0.010)	0.197*** (0.010)	0.196*** (0.010)	0.194*** (0.004)	0.194*** (0.004)
Province-year FE	+	+	+	+	+
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

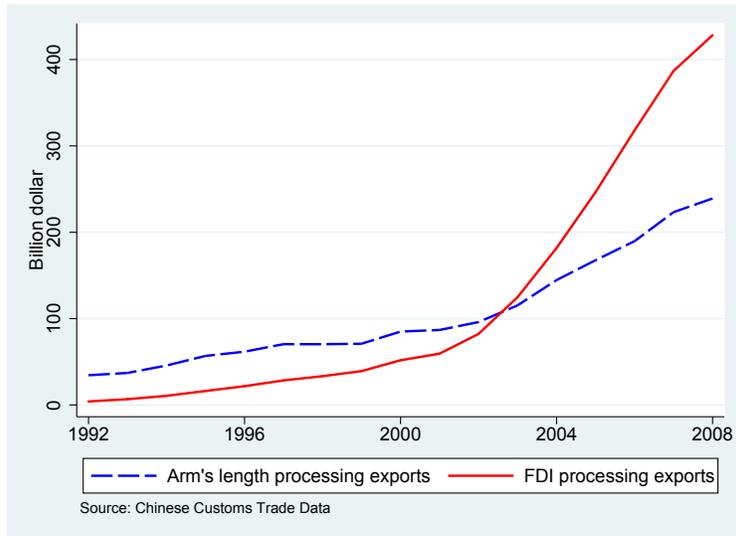
Note: The dependent variable is log (annual wage income). The province-year cluster robust standard errors are enclosed in parentheses for Columns (1)-(3). *, **, and *** indicate significance at the 10, 5, and 1 percent levels.

^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.

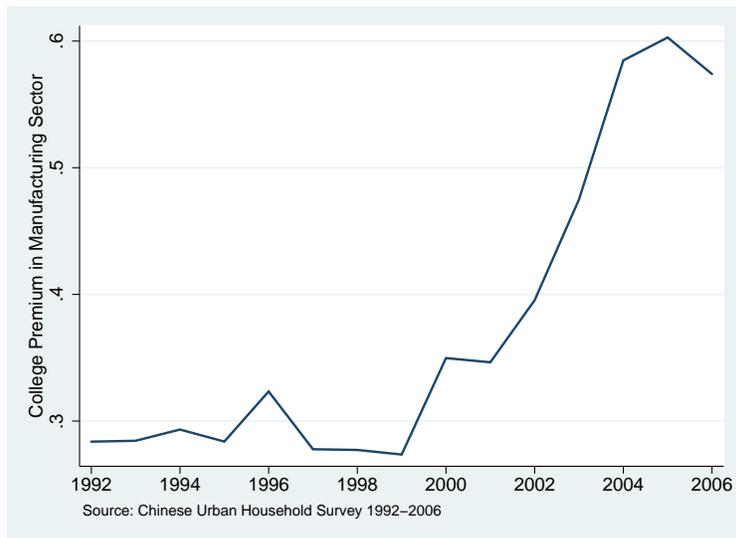
Table 5: Sensitivity Analysis on the Determinants of College Premium

	Migration Cost	Cul. Rev. cohort	Non-CR cohort	Male only	Female only	All trade partners
	(1)	(2)	(3)	(4)	(5)	(6)
College indicator	0.221*** (0.020)	0.133*** (0.020)	0.261*** (0.024)	0.187*** (0.031)	0.302*** (0.036)	0.219*** (0.019)
College indicator interaction terms						
College × Processing exports ratio	0.535*** (0.151)	0.348* (0.179)	0.498*** (0.176)	0.440*** (0.145)	0.785** (0.272)	0.482*** (0.144)
College × Share of FDI processing exports	0.293*** (0.050)	0.301*** (0.082)	0.256*** (0.058)	0.333*** (0.058)	0.190** (0.075)	0.285*** (0.058)
College × Ordinary exports ratio	-0.265* (0.139)	-0.382 (0.286)	-0.071 (0.202)	-0.479** (0.195)	0.370 (0.320)	-0.153 (0.206)
College × R&D ratio	1.570*** (0.528)	0.216 (0.811)	2.007*** (0.634)	1.794** (0.877)	0.678 (0.867)	1.226*** (0.488)
College × Capital-output ratio	0.024* (0.013)	0.056* (0.026)	0.010 (0.016)	0.034 (0.018)	-0.013 (0.023)	0.024* (0.013)
College × Reduction in migration cost	0.006 (0.009)					
Individual characteristics						
Experience	0.047*** (0.001)	0.039*** (0.005)	0.044*** (0.001)	0.052*** (0.001)	0.047*** (0.001)	0.047*** (0.001)
Experience square	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Sex	-0.208*** (0.004)	-0.217*** (0.006)	-0.205*** (0.005)			-0.209*** (0.003)
State owned sector	0.194*** (0.003)	0.243*** (0.006)	0.170*** (0.005)	0.151*** (0.005)	0.235*** (0.006)	0.194*** (0.004)
Province-year FE	+	+	+	+	+	+
First stage F-stat	> 368.2	> 271.72	> 224.91	> 248.29	> 216.38	> 177.48
Observations	143,010	51,775	91,235	79,086	63,924	143,010
R-squared	0.303	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

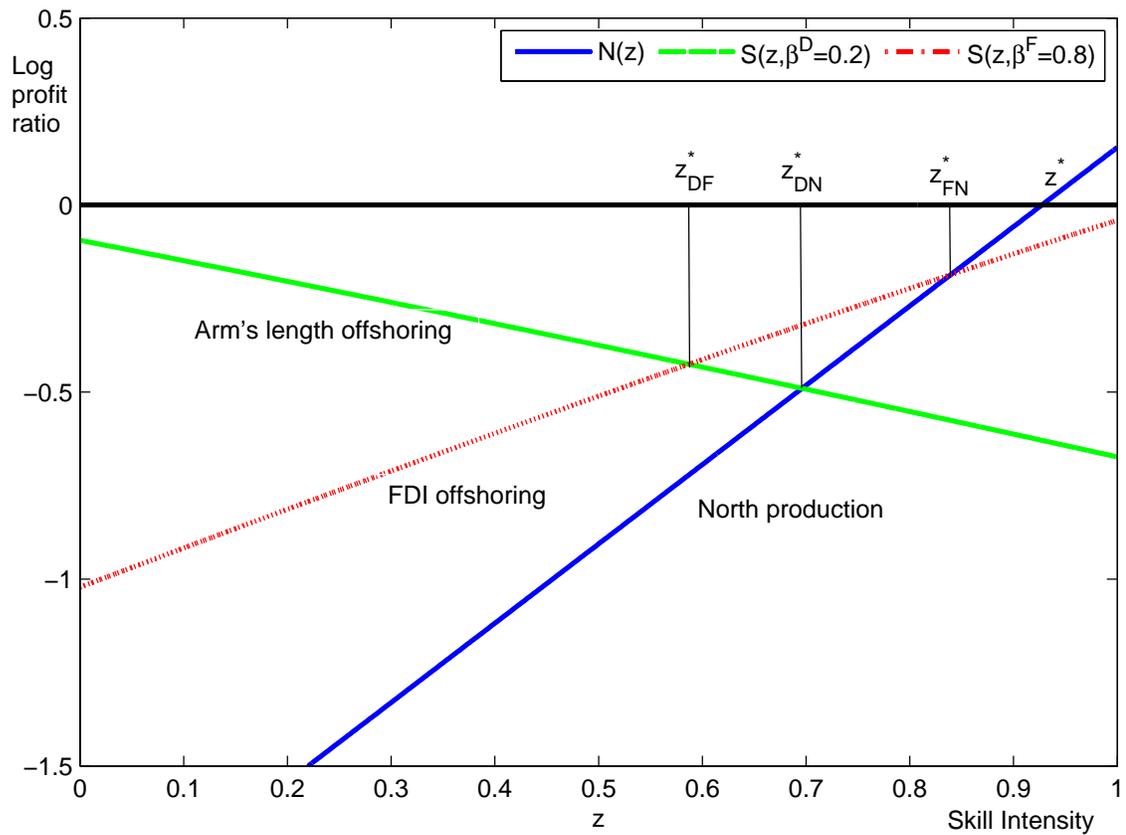


Figure 2: Optimal Ownership of Offshoring and Skill Intensity of Intermediate Goods

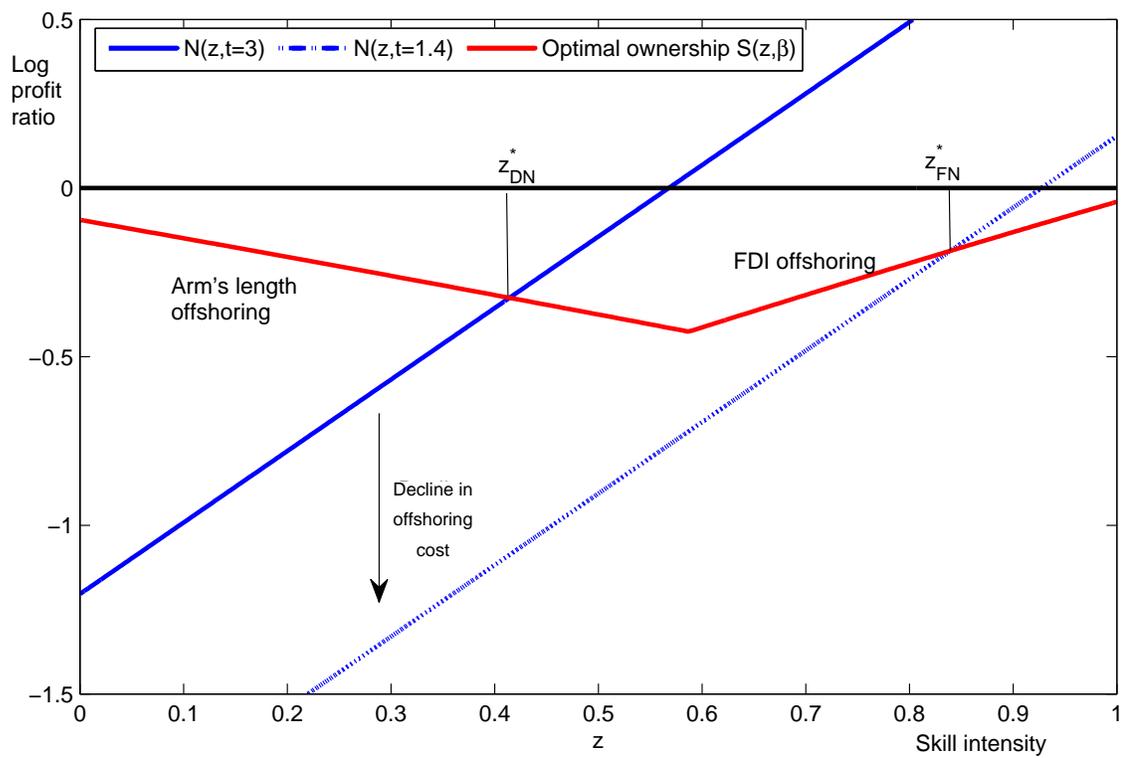


Figure 3: Reduction in Offshoring Cost and Skill Intensity of Intermediate Goods

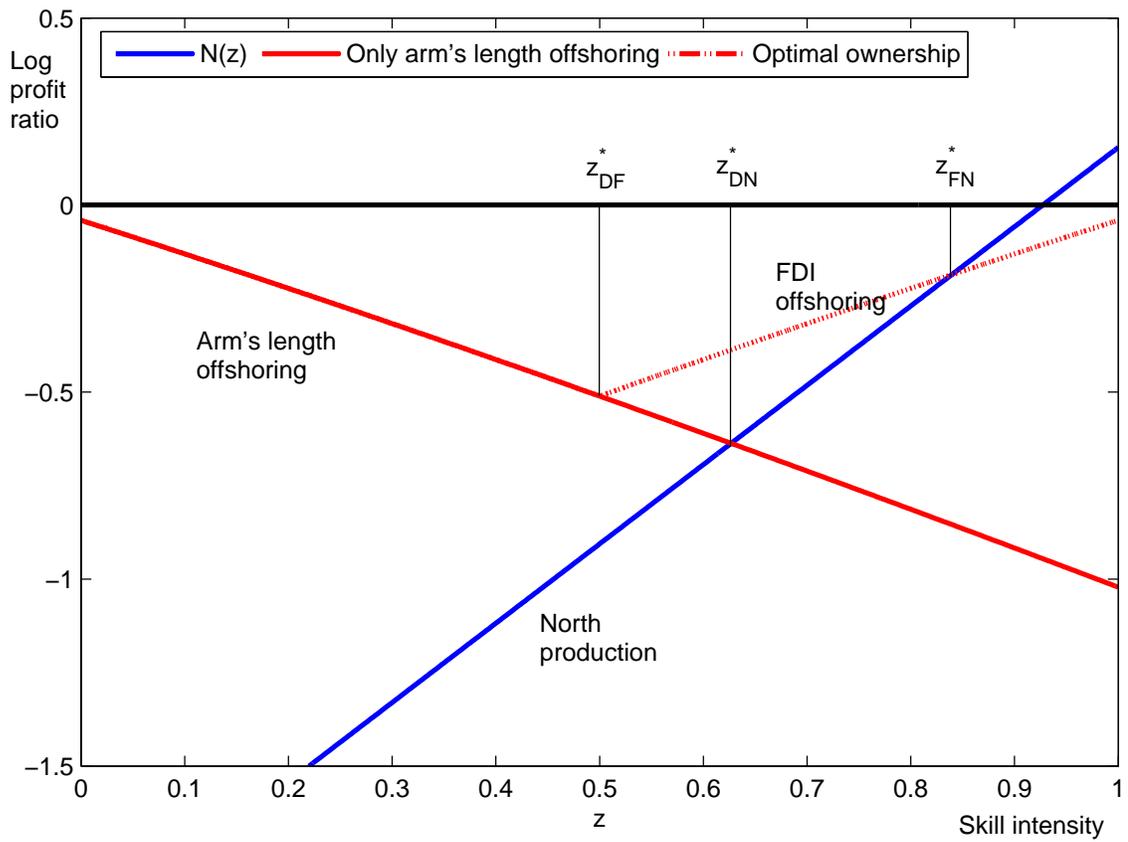
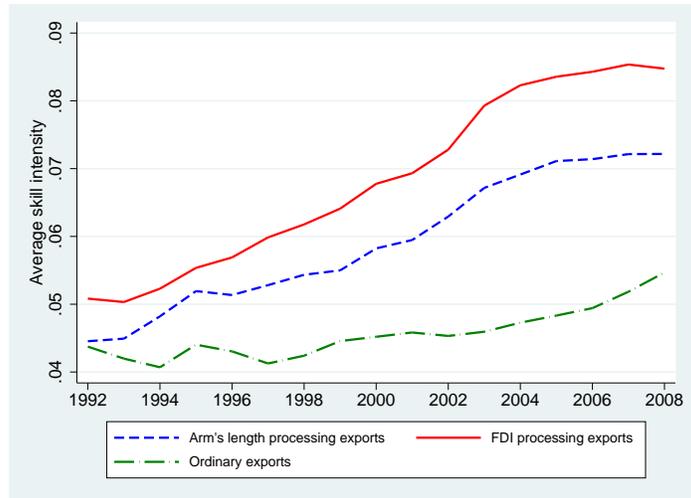
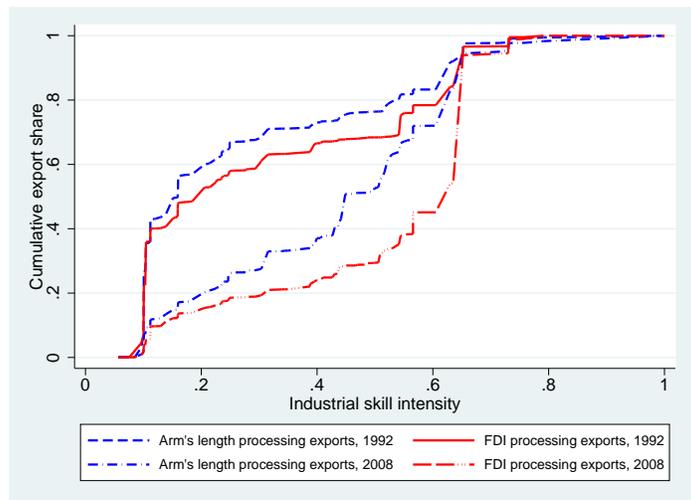


Figure 4: Ownership Liberalization, Offshoring, and Skill Intensity of Intermediate Goods



(a) Average Skill Intensity



(b) Skill Upgrading

Figure 5: Skill Content of Processing Exports

Online Appendix

Not for Publication

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

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

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 .

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

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 $\beta > 1/2$, $\frac{\partial S(z, \beta)}{\partial z} > 0$, $S(z = 0, \beta) < S(z = 0, 1/2) = S(z = 1, 1/2) < S(z = 1, \beta) \leq 0$. Given that $\beta^F > 1/2$, the log profit ratio of foreign-owned firms increases in z .
- (c) For $\beta < 1/2$, $\frac{\partial S(z, \beta)}{\partial z} < 0$, $S(z = 1, \beta < 1/2) < S(z = 1, 1/2) = S(z = 0, 1/2) < S(z = 0, \beta < 1/2) \leq 0$. 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

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

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 β while $S(z = 1, \beta)$ 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

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

Thus, $N(z) > S(z, \beta)$ is equivalent to $B(z, \beta, t) > 0$, and vice versa. Based on Assumption 1, we show the following corollary:

Corollary 3

- (1) *If Assumption 1 holds, for a given value $\beta < \tilde{\beta}$, we have $\lim_{z \rightarrow 0} B(z, \beta, t) < 0$, $B(1, \beta, t) > 0$, 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. $\lim_{z \rightarrow 0} B(z, \beta, t) < 0$ holds only if the term in the bracket is negative, which is true under the Assumption 1(2). Moreover,

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

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 $r(0, \beta) < r(0, \tilde{\beta}) = 0$ for $\beta < \tilde{\beta}$. The last strict inequality holds due to Assumption 1(2). Thus, $B(z, \beta, t)$ is an increasing and continuous function of z , and $B(1, \beta, t) > 0$, $\lim_{z \rightarrow 0} B(\beta, z, t) < 0$. 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 respect 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.

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

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

$$RS^F(t) = \frac{\int_{z_{JF}^*}^{z_{FN}^*(t)} R(z, \beta^F) dz}{\int_0^{z_{DF}^*} R(z, \beta^D) dz + \int_{z_{DF}^*}^{z_{FN}^*(t)} R(z, \beta^F) dz} = \frac{\int_{z_{JF}^*}^{z_{FN}^*(t)} \tilde{R}(z, \beta^F) dz}{\int_0^{z_{DF}^*} \tilde{R}(z, \beta^D) dz + \int_{z_{DF}^*}^{z_{FN}^*(t)} \tilde{R}(z, \beta^F) dz}$$

where $\tilde{R}(z, \beta) = R(z, \beta)/(\frac{1}{t})^{\alpha/(1-\alpha)}$ 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 \bar{z} denote the cutoff between North-South production.

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

due to the fact that $h(\bar{z}, \beta^F)/l(\bar{z}, \beta^F) \geq h(\bar{z}, \beta^O)/l(\bar{z}, \beta^O) > h(z, \beta^O)/l(z, \beta^O)$ for $z < \bar{z}$, 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: $[h(\bar{z}, \beta^F)/l(\bar{z}, \beta^F) - h(z, \beta^O)/l(z, \beta^O)] = [\frac{h(\bar{z}, \beta^F)}{l(\bar{z}, \beta^F)} - \frac{h(\bar{z}, \beta^O)}{l(\bar{z}, \beta^O)}] + [\frac{h(\bar{z}, \beta^O)}{l(\bar{z}, \beta^O)} - \frac{h(z, \beta^O)}{l(z, \beta^O)}]$. 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

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

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

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

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 $h(z, \beta^D)/l(z, \beta^D) \geq h(y, \beta^D)/l(y, \beta^D)$ for $z \geq y$.

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

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

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 $h(z, \beta^F) \geq h(z, \beta^D)$ and $l(z, \beta^D) \geq l(z, \beta^F)$ for $z \in [0, 1]$.

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

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 $l(z, \beta^D) \geq l(z, \beta^F)$, 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

$$\int_{\Omega_3} h(z, \beta^F) dz / \int_{\Omega_3} l(z, \beta^F) dz > \int_{\Omega_{1,2}} h(z, \beta^D) dz / \int_{\Omega_{1,2}} l(z, \beta^D) dz,$$

which indicates 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 Sensitivity Analysis of China's Processing Exports

Table F.1: Robustness Check on China's Processing Exports

	(1) Tariffs	(2) Non-MFA	(3) Ind-spec linear trend
FDI indicator	-1.206*** (0.060)	-1.192*** (0.066)	-1.191*** (0.062)
Enc. policy	0.097 (0.074)	0.106 (0.075)	0.201** (0.092)
Res. Policy	-0.056 (0.055)	-0.066 (0.057)	0.053 (0.066)
FDI × Enc. Policy	0.233*** (0.055)	0.195*** (0.061)	0.192*** (0.055)
FDI × Res. Policy	-0.438*** (0.060)	-0.345*** (0.065)	-0.434*** (0.059)
FDI × Natl. policy zones	0.080*** (0.009)	0.075*** (0.009)	0.080*** (0.009)
FDI × Infrastructure	0.209** (0.093)	0.221** (0.098)	0.204** (0.096)
Skill intensity × College share	0.882*** (0.081)	0.884*** (0.076)	0.659*** (0.081)
Capital intensity × Capital output ratio	0.006** (0.003)	0.004 (0.003)	0.007** (0.003)
Contract intensity × Court efficiency	0.143*** (0.012)	0.129*** (0.012)	0.146*** (0.012)
Ln(1+Weighted external tariff)	-0.856* (0.498)		
Ln(1+NTRgap)	0.131 (0.359)		
Industry FE	+	+	+
Prov-Year FE	+	+	+
Observations	36,043	33,053	36,158
R-squared	0.530	0.516	0.541

Note: The dependent variable is log (processing exports value) in all three columns. The last column includes industry-specific trends as additional control variables. The province-year cluster robust standard errors are enclosed in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels.

F.3 Augmented Mincer Wage Regressions

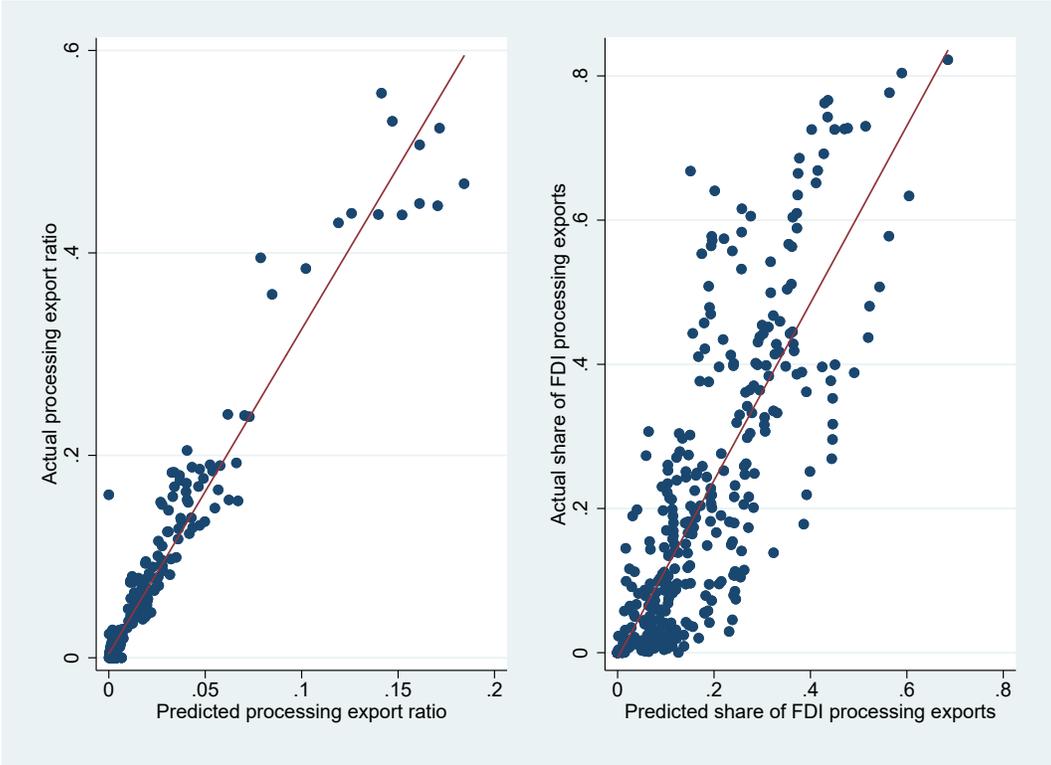


Figure F.1: Scatter Plots for First-Stage Regression

Table F.2: Effect of Policy Zones and Infrastructure on the Changes in College Premium

Variables	$\Delta Coll.prem_{92-00}$					
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Coll.prem</i> ₁₉₉₂	-0.845*** (0.217)	-0.814*** (0.244)	-0.949*** (0.219)	-0.913*** (0.241)	-0.931*** (0.223)	-0.867*** (0.238)
<i>Natlzone</i> ₁₉₉₂	0.006 (0.010)	0.011 (0.013)	0.004 (0.010)	0.007 (0.013)	0.003 (0.010)	0.008 (0.014)
<i>Infrastructure</i> ₁₉₉₂	-0.102 (0.071)	-0.075 (0.091)	-0.060 (0.045)	-0.020 (0.062)	-0.042 (0.036)	0.009 (0.051)
Control variables		+		+		+
Observations	29	28	29	28	29	28
R-squared	0.459	0.474	0.496	0.515	0.424	0.457

Note: Three different measures of college premium estimated from the Mincer regression are used as dependent variables. Columns (1) and (2) use the unconditional college premium, Columns (3) and (4) use conditional college premium with controls for individual characteristics, including age, sex, experience and its square, and Columns (5) and (6) use college premium with additional controls for state-sector indicators. Columns (2), (4), and (6) include capital-output ratio, R&D ratio, and log real GDP per capita as control variables. Robust standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels.

Table F.3: Years of Education and Schooling Returns

	OLS		IV
	(1)	(2)	(3)
Schooling years	0.063*** (0.002)	0.040*** (0.005)	0.040*** (0.003)
Interaction terms of schooling years			
Schooling years \times Processing exports ratio		0.040** (0.018)	0.050** (0.019)
Schooling years \times Share of FDI processing exports		0.072*** (0.007)	0.073*** (0.007)
Schooling years \times Ordinary exports ratio		-0.110** (0.047)	-0.161*** (0.024)
Schooling years \times R&D ratio		0.338* (0.205)	0.574*** (0.076)
Schooling years $\times K/Y$		0.006 (0.004)	0.007*** (0.002)
Individual characteristics			
Experience	0.048*** (0.001)	0.048*** (0.001)	0.046*** (0.001)
Experience square	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Sex	-0.195*** (0.006)	-0.194*** (0.006)	-0.200*** (0.003)
Stated owned sector	0.176*** (0.010)	0.178*** (0.010)	0.176*** (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 statistical 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.4 Provincial Variables

Table F.4: 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.5: 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					
Variables	Obs	Mean	Std. Dev.	Min	Max
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