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

Liugang Sheng and Dennis Tao Yang

March 19, 2017

[†]Contact information: Sheng, Department of Economics, The Chinese University of Hong Kong, Hong Kong; Email: lsheng@cuhk.edu.hk; Yang, Darden School of Business, University of Virginia, Charlottesville, Virginia; E-mail: yangd@darden.virginia.edu. We would like to thank Robert Feenstra and Pol Antràs for their valuable guidance, and thank Costas Arkolakis, Paul Bergin, Andrew Bernard, Davin Chor, Zhiyuan Li, Justin Lin, Dan Lu, Lindsay Oldenski, John Ries, Andrés Rodríguez-Clare, John Romalis, Katheryn Russ, Deborah Swenson, and Heiwai Tang, as well as the seminar and conference participants from various institutions for their useful comments and suggestions. All remaining errors are our own.

Abstract

We present a global production sharing model that integrates the organizational choices of offshoring with the determination of relative wages in developing countries. The model shows that offshoring through foreign direct investment (FDI) 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 (WTO) in 2001. Empirical findings based on detailed Urban Household Surveys and trade data from Chinese customs provide support to the proposed theory, thus shedding light on the changes in firm ownership structure, the skill content of exports, and the evolution of wage inequality for the period of 1992-2008 in China.

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

JEL classification: F16, J31, D23

1 Introduction

In recent decades, trade in intermediate inputs through FDI and arm's length offshoring have gained prominence in the global economy. Now approximately two-thirds of the world trade consist of transactions in intermediate inputs, and approximately half of that is within the boundaries of multinational companies (MNCs).[1] The dramatic rise of offshoring has stimulated a burgeoning literature that improves our understanding of its microeconomic structure and effect on wage inequality. Seminal papers, such as those of Antràs (2003) and Antràs and Helpman (2004), have investigated firm's offshoring decision and organizational choices between FDI and outsourcing. A key insight is that the ownership structure of offshoring crucially 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. Somewhat surprisingly, existing studies have not yet explored systematically the effects of microeconomic structure of offshoring on wage inequality in developing countries, despite of 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 with the determination of relative wages in developing countries, drawing 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," the top destination among developing countries. Foreign firms contributed approximately one third of the gross industrial output of China.[3] Second, China provides an intriguing natural experiment of changing policy regimes in regulating foreign investment.

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

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

[3]According to the yearbook of China's National Bureau of Statistics (NBS), foreign firms accounted for 32% and 28% of gross industrial output and value added in 2006, and approximately half of that was from wholly foreign-owned firms. NBS stopped reporting this figure after 2006, but the contribution of foreign firms has grown in the past decade.

Until the late 1990s, the Chinese government had imposed restrictions on wholly foreign-owned companies, but encouraged joint ventures and arm's length offshoring. However, upon its accession to the WTO, China had to relax ownership restrictions on multinationals in the manufacturing sector. Since then, wholly foreign-owned affiliates have grown extensively, becoming the dominant force in foreign investment and processing trade. This ownership liberalization on MNCs, which is induced largely by external factors, presents a unique opportunity to investigate the effects of 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 with this timing, Figure 1(b) illustrates that the college wage premium in the Chinese manufacturing sector remained rather flat before 2001, but increased dramatically thereafter. The average earnings gap between workers with and without college education was approximately 30% throughout the 1990s, but the skill premium increased to 55% by 2006. These empirical observations raise important questions that this papers seeks to answer. What policies and institutions may affect the composition of FDI and arm's length offshoring to the South? How do different types of offshoring influence skill demand in developing countries and therefore affect 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 property rights theory (Grossman and Hart, 1986; Antràs, 2005) into the offshoring framework (Feenstra and Hanson, 1996), the model

[4]FDI offshoring is measured as processing exports by wholly foreign-owned enterprises, whereas arm's length offshoring is defined as processing exports by joint ventures and Chinese domestic firms. We use processing exports as a measure of offshoring because it involves a foreign firm that either works with its own affiliates or contracts with local firms to assemble imported inputs with local factors and re-export the 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 the international trade in China, accounting for an average of 56% of the total exports of the country from 1992 to 2008.

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 skill demand in the South. The first channel is the Feenstra-Hanson mechanism through which relatively more skill-intensive products offshored from the North increases skill demand in the South. The second is the ownership mechanism (e.g., Antras, 2003; Antras and Helpman, 2004; hereafter, the Antras mechanism): 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 on multinationals and reduction in offshoring cost in host countries, that can attract FDI offshoring, thus increasing demand for and returns to skill in the South. The ownership mechanism forges a novel and potentially important linkage between offshoring and skill premium, given that ownership restrictions and high offshoring cost are prevalent 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 data sets covering the period 1992-2008: (a) the national sample of Urban Household Surveys (UHS), which contains rich household and individual information on earnings and demographic characteristics; (b) Chinese customs trade data with detailed descriptions of by-product export and firm characteristics; and (c) aggregate variables that capture the institutional and economic conditions of labor markets at the province level. Moreover, we constructed two indicator variables for "encouragement" and "restriction" policies by industry based on a series of government deregulation policies that liberalized the ownership structure of MNCs. Local offshoring costs were also measured using information on 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, ownership liberalization on multinationals and reduction in offshoring costs generate an asymmetric effect: they increase 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, given that the UHS and customs trade data cover 30 Chinese provinces for 16 years. Regression estimates indicate that aggregate offshoring (the Feenstra-Hanson mechanism) and the share of FDI offshoring (the Antras 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. FDI offshoring can quantitatively explain approximately 50% of the total increase in college wage premium in Chinese manufacturing 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 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 MNC's organizational choice, namely regulations on foreign ownership and government policies affecting offshoring costs, which complement the existing emphasis on incomplete contracts. To the best of our knowledge, this study is the first to identify the significant effect of organizational structure of offshoring on wage inequality in a large developing country. Therefore, this paper also contributes to a broader literature of 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) and Hummels et al. (2014)). This study departs from the literature by distinguishing FDI from arm's length offshoring. The differential effects of the two types of

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

offshoring on the demand for skill highlight the importance of policy reforms in developing countries, because removing restrictions on foreign ownership and lowering offshoring costs can induce MNCs to transfer skill-intensive production to the South. Goldberg and Pavcnik (2007) points out that research on the effect of globalization on income distribution in China is limited,[6] despite the fact that "China trade shock" has attracted the attention of researchers since the work of Autor et al. (2013). Therefore, this paper fills a void in the literature by shedding light on the evolving income distribution in China as well as the effect of globalization on inequality given China's increasing significance in the global economy.

The remainder 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 The Model

In this section, we develop a 2-country $\times$ 2-factor model to study the joint decisions of MNCs on offshoring, ownership structure and the intensity of skill subject to contractual frictions and the institutional environment of host country. The model forges a new linkage between the organizational choice of MNCs and the demand for skill in the South. We apply the model to investigate the consequences of two policy reforms—namely, ownership liberalization on MNCs and reductions in offshoring cost—for 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 immobile across the border: high- and low-skilled labors, denoted by h and l respectively. Their

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

wages in country c are denoted by q^c and w^c, respectively, where $c \in \{N, S\}$. The North has more abundant high-skilled labor than the South. We assume that the North produces both the final good Y and intermediate goods, while the South only produces intermediate goods.

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

The production of the intermediate good z is given by $y(z) = \xi_z x_h^z x_l^{1-z}$, where $\xi_z = z^{-z}(1 - z)^{-(1-z)}$, and $0 \leq z \leq 1$. x_h is the high-tech input and x_l is the low-tech input. A higher z indicates more intensive use of high tech in production. The model builds on Antràs (2005), but has several significant differences. First, Antràs (2005) only concisders one type of labor, whereas we specify two types of labor to explore the impact of offshoring on the demand for skill. For simplicity, we assume that one unit of high-tech (low-tech) input requires one unit of high-skilled labor h (low-skilled l).[7] Second, as in Feenstra and Hanson (1996, 1997), we assume that the production for each intermediate good $y(z)$ is not fragmentable, i.e., the two inputs are produced at the same location for manufacturing the good z.[8] While Antras analyzes the processes of innovation and production in the context of the product cycle, we focus on the effects of offshoring on relative wages in the South.

For any intermediate good z, only the Northern innovator has the technology (blueprint) to produce the high-tech input, but she has to find a low-tech input supplier in the North or South. The investments by the two parties are assumed to be relation specific. The supplier also pays the innovator a lump-sum transfer T, which would make the supplier break even. If the North-

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

[8]In Feenstra and Hanson (1996, 1997), MNCs can offshore the production of intermediate goods, but it is not fragmentable. In contrast, Grossman and Rossi-Hansberg (2008) and Antràs (2005) assume fragmentable production, i.e., the North can offshore the high or low input production to the South separately. The reality is likely in between these two apporaches. See Feenstra (2010) for a discussion on their implications for offshoring and wage inequality.

ern innovator sources the low-tech inputs from domestic suppliers, the contract is assumed to be complete. If she offshores the inputs, however, she faces incomplete contracts because the legal environment in the South is poor. Moreover, the Northern innovator can choose the ownership of their joint production. She can either set up a foreign affiliate ($O = F$), or outsource to the Southern suppliers ($O = D$). Beside the incomplete contract, offshoring requires an additional effort in managing business overseas (Grossman and Rossi-Hansberg, 2008). We assume this offshoring cost is proportional to the output of good z, which means that for one unit of z, the offshoring cost is $t - 1$ units where $t \geq 1$.

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

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

If the Northern innovator opts to offshore, the innovator and the Southern supplier will bargain over the surplus from their relation-specific investment after production due to incomplete contracts. Thus, the supplier sets l^S to maximize $(1 - \beta)R(z) - w^S l^S$, and the innovator sets h^S to maximize $\beta R(z) - q^S h^S$, where $R(z) = \lambda^{1-\alpha} y(z)^\alpha / t^\alpha$ and $\beta \in [0, 1]$ denotes the revenue share of the Northern innovator. The Northern firm finalizes the contract by setting T so as to make the low-tech supplier break even and obtain the *ex ante* profit as follows:

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

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

The Northern innovator's revenue share β is determined by the ownership structure. If the innovator owns the firm ($O = F$), once they did not achieve agreement on the bargaining, the innovator can fire the low-tech supplier, who will be left with nothing. But the innovator can still obtain δ fraction of the output, where $0 < \delta < 1$, generating a revenue of $\delta^\alpha R$. The quasi-rent of this relationship is $(1-\delta^{\alpha})R$. Symmetric Nash Bargaining leaves each party with its outside option plus one-half of the quasi-rent. Thus, the ex post revenue share of the Northern innovator is $\beta^F = \frac{1}{2}(1+\delta^{\alpha})$. By contract, if the Southern supplier owns the firm ($O = D$), the innovator's share in revenue is $\beta^D = \frac{1}{2}(1-\delta^{\alpha})$. Clearly we have $0 < \beta^D < 1/2 < \beta^F < 1$.[9]

2.2 Sourcing Location and Ownership Choice

The Northern innovator's ex ante profit is given by $\pi(z) = \max\{\pi^N(z), \pi^S(z, \beta^F), \pi^S(z, \beta^D)\}$. Comparing to the North, the South has abundant cheap low-skilled labor, but it suffers the iceberg offshoring cost and efficiency loss due to the incomplete contracts. To separate the effect of comparative advantage and offshoring costs from the frictions of incomplete contracts on offshoring, we introduce a hypothetical 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 the hypothetical case in which both the North and the South have complete contracts. Let $N(z)$ denote the corresponding "log profit ratio" of the Northern production relative to the Southern production:

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

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

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

a reduction in offshoring costs help to attract more skill-intensive products to relocate to the South.

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

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

$\beta \in (0,1)$. 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 only depends on the skill intensity of the product. Appendix A shows that $S(z,\beta)$ is supermodular in (z,β), concave in z, and strictly concave in β. Thus, for a given value of $z \in [0,1]$, there is a unique maximizer $\beta^*(z) \in [0,1]$, and $\beta^*(z)$ increases in z. Supermodularity implies that optimal revenue share of the Northern innovator is (positively) determined by the skill intensity of the intermediate goods z, a result that captures the spirit of the property right theory of the firm (Grossman and Hart, 1986; Hart and Moore, 1990). In Appendix B, we also show that among those 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.

Now, we 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 pattern of global production and ownership structure, we assume:

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

This assumption essentially rules out the extreme cases that all products are produced in one location. The first part guarantees that the most skill-intensive product $z = 1$ is produced in the

North, and the second part guarantees that the least skill-intensive product $z = 0$ is produced in the South.[10] Figure 2 plots three curves of log profit ratios: $N(z), S(z, \beta^D)$, and $S(z, \beta^F)$. The detailed properties of those curves have been discussed in Appendix C. Clearly, the optimal choice of the innovator is the upper contour of the three log profit ratios. Based on this assumption, we can present our main proposition:

Proposition 1 *If Assumption 1 holds and three production modes coexist, 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 Antràs (2005).[11] Figure 2 is also useful to disentangle the role of comparative advantage and incomplete contracts on global production sharing in an integrated framework. Note that the horizontal axis presents the benchmark: 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 characterize global production sharing with the North-South cutoff $z^*(t)$ in the contractual frictionless world of Feenstra and Hanson (1997). To the left of the cutoff, the South specializes in less skill-intensive products because of 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 $N(z)$, $S(z, \beta^D)$ 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 efficiency loss both at the intensive margin, i.e., a profit loss for any given z when production takes in the South, and at the extensive margin because

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

[11] This proposition shows the pattern in which three production modes coexist. Under certain conditions, however, FDI offshoring may not exist. Figure 2 provides a sufficient frameworks to conduct a general analysis.

less products would be offshored to the South due to 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 potentially offshorable to the South are skill-intensive, thus mostly 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 incomplete contracts in the South.

2.3 Ownership Liberalization and Offshoring Cost

The model developed above can be applied to analyze the effects of ownership liberalization and reduction in offshoring cost on the patterns of offshoring. Figure 3 shows that a decline in offshoring cost can be captured by shifting down the curve $N(z)$ from the solid line to the dotted line. Initially, when offshoring cost is high, the equilibrium is at z^*_{DN}: the Northern innovator only outsource limited low skill-intensive products through arms' length contracting because high offshoring cost dampens the comparative advantage of production in the South. There is no FDI offshoring, even if foreign ownership is legally allowed. As 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 would find it profitable to also offshore more skill-intensive products to the South through their foreign affiliates. The model suggests that, when both organization forms coexist as shown in Figure 2, reductions in offshoring costs have a stronger effect on FDI offshoring than on arm's length offshoring in terms of export revenue. While Appendix D presents the proof of this result, the intuition is straightforward. Because the revenue elasticities of offshoring cost is $-\alpha/(1-\alpha)$ for both ownership types, a decline in offshoring costs 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 arm's length transactions. As a result, the export share of FDI offshoring increases with falling trade cost.

Our model also provides a framework to analyze the impact of ownership restriction and liberalization of foreign investment on the export structure in the South. Governments in developing countries often interfere with ownership structures of FDI for reasons including reducing competition with indigenous firms, promoting technology transfer through joint ventures, and protecting strategic sectors (e.g., Kobrin 1987; Gomes-Casseres 1990). 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 economy settles at the intercept of $S(z, \beta^D)$ and $N(z)$, where z^*_{DN} is 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 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 skill-upgrading through the relocation of more skill-intensive production to the South. Correspondingly the expansion of FDI offshoring generates efficiency gains for the economy–reflected by the triangle area below $S(z, \beta^F)$ and above $S(z, \beta^D)$ and $N(z)$–through optimizing the ownership structure.[12] The proposition below summarizes our findings.

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

2.4 Skill Premium

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

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

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

This proposition indicates two channels through which offshoring increases skill demand in the South. The first is the extensive margin: skill demand increases when more skill-intensive intermediate goods with higher z are offshored to the South. The second is the intensive margin: 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. Next, we define the aggregate relative skill demand in the South as follows:

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

where Ψ denotes the ownership choice set, i.e., $\Psi = \{\{\beta^D\}, \{\beta^D, \beta^F\}\}$. $\Omega_\Psi = [0, z^*_{DN}]$ if $\Psi = \{\beta^D\}$ and $\Omega_\Psi = \Omega_D \cup \Omega_F = [0, z^*_{DF}] \cup [z^*_{DF}, z^*_{FN}]$ if $\Psi = \{\beta^D, \beta^F\}$. We 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 $0 < \alpha \leq 1/2$*, 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 appear 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 the demand for skill is rather limited when arm's length outsourcing is the only option. Proposition 4 (2) presents the Antràs' ownership mechanism. Once the ownership restriction is removed, the aggregate relative skill demand increases through both the extensive and intensive margins: more skill-intensive products are offshored by foreign affiliates, and there is higher skill demand when firms switch from arm's length offshoring to FDI offshoring.

Because the aggregate relative skill demand has a downward slope with $0 < \alpha \leq 1/2$, and with the assumption of exogenously given relative skill supply, the skill premium increases as the aggregate relative skill demand shifts up 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 the skill premium. We apply the result in Proposition 3 to augment the Mincer earnings function that connects aggregate demand for skill to an empirical specification that is amenable for estimating the impact of offshoring on wage inequality. In this section, we also describe three data sets used for empirical analysis and explain the measurement of two key explanatory variables, namely FDI ownership liberalization and offshoring costs that are related to Chinese institutions and geography.

3.1 An Augmented Mincer Equation

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

$$\ln W\left(C, \mathbf{\Phi}\right) = \alpha_0 + \alpha_1 C + \alpha_2' \mathbf{\Phi} + \varepsilon, \tag{6}$$

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

The coefficient of the dummy variable of schooling represents college wage premium in percentage terms, i.e., $\alpha_1 = E(\ln W|C = 1, \mathbf{\Phi}) - E(\ln W|C = 0, \mathbf{\Phi}) = ln(q/w)$, where q and w are the market equilibrium wages for college and non-college workers in the South, as specified in equation (3). Proposition 3 establishes a direct linkage between the college wage premium (q/w) and the relative demand for high-skilled versus low-skilled workers in the South $h(z, \beta)/l(z, \beta)$. More importantly, equation (5) implies that the college wage premium increases with the aggregate relative skill demand through its inverse function $ln(q/w) = lnD^{-1}(t, \Psi)$, where a decline in offshoring cost t and an expansion on 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:

$$\ln W\,(C, \mathbf{\Phi}, t, \Psi) = \alpha_0 + \alpha_1(t, \Psi)C + \alpha_2' \mathbf{\Phi} + \epsilon. \tag{7}$$

3.2 A Two-Stage Procedure

While equation (7) implies a direct connection between (t, Ψ) and college wage premium, our offshoring model provides a structural framework that allows a deeper investigation into the mechanisms through which offshoring affects the skill premium. Proposition 2 suggests that falling offshoring costs and relaxing controls on MNCs' ownership choice not only increase the total offshoring measured by R but also the share of FDI offshoring $RS^F = R^F/R$. As a result, more skill-intensive production is shifted to the South to realize the gains of comparative advantage and optimizing the ownership structure.

Therefore, in the first stage, we assess the role of (t, Ψ) in determining the level and composition of offshoring:

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

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

In the second stage, we examine local labor market outcomes of trade shocks by exploring spatial variations in regional exposure to FDI and arm's length offshoring. More specifically, we estimate the augmented Mincer regression consisting of interaction terms of the college indicator C with regional total offshoring (R) (scaled by industrial output) and the share of FDI offshoring (RS^F):

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

Propositions 2 and 4 suggest that the coefficients (α_{11} and α_{12}) estimated for both interaction terms are positive. The first coefficient presents a test for the Feenstra-Hanson mechanism in which the skill premium increases when more processing products are offshored to the South. The second coefficient sheds light on the Antràs ownership mechanism on 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 the skill premium.

The two-stage identification strategy performs direct tests to the main propositions (2) and (4) of our model. The first stage assesses the effects of a reduction in offshoring cost and ownership liberalization of MNCs on the patterns of offshoring, and the second stage identifies what types of offshoring matter for the skill premium. Another advantage of the strategy is to deal with the selection bias of multinational companies in which MNCs choose regions for offshoring based on local conditions such as the quality the 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 exogenous variables (t, Ψ) to predict the variables (R, RS^F) in equation (8), which can serve the instrument variables and help mitigate the endogeneity problems in estimating the effects of offshoring on the skill premium in equation (9). We will clarify these specification issues and deal with the ability bias embedded in the estimation of Mincer regressions in later empirical analyses.

We acknowledge that an implicit assumption, which enables us to explore the rich spatial variations in exposure to trade shocks, is low labor mobility across regions in China. If labor is freely mobile across regions, market forces would tend to equilibrate the skill premia across regions, thus making it difficult to identify the effects of offshoring on wage inequality. The literature on regional adjustments to labor-market shocks suggests that mobility responses to labor demand shocks across regions are slow and limited, particularly in developing countries such as China.[13] China has a household registration (or *Hukou)* system that imposes large costs of working and living outside one's *Hukou* region. According to Tombe and Zhu (2015)'s estimate for 2000, the average cost of inter-province migration is close to a worker's one-year income and the migration cost only decreased slightly from 2000 to 2005. The large regional income disparity across the Chinese provinces is a good indication of how tightly migration costs bind. In our urban household survey data, the average wage ratios for non-college and college workers of the 90th to 10th percentile of provinces were 2.95 and 2.88 in 1992, respectively. In contrast, the corresponding ratios were around 1.5 on average for the two types of labor across the states in the U.S.. These regional wage ratios did not decline but increased slightly to 2.96 and 3.01 in 2006. In the context of persistent regional wage gaps and limited labor mobility across Chinese provinces, we will explore regional variations to identify the impact of offshoring on labor market outcomes.

3.3 Data and Policy Variables

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

The experiment of ownership liberalization for foreign investment in China provides a unique opportunity to test our model. As early as 1979, the Chinese government started to encourage

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

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

We construct a unique measure of ownership liberalization using the official government list (CGFII) of industries that were encouraged, and restricted (or prohibited) for foreign investment. The CGFII was first published in 1995 and was revised subsequently in 1997, 2002, 2004, and 2007. In encouraged industries, foreign investors were given more freedom to choose their ownership structures and enjoyed other advantages, such as preferable corporate tax rates, low land costs, and duty-free imported inputs. By contrast, the Chinese government imposed stringent restrictions on ownership structures and high entry costs for foreign investors in restricted or prohibited industries. For subsequent regression analysis, we construct two proxies for ownership liberalization at the industry level: an encouragement policy indicator and a restriction (including prohibited) policy indicator. We assign the value of 1 for encouragement (or restriction) policy in an industry if at least one product in that industry is formally stated on the government's list of encouragement (or restriction), i.e., $EP_{it} = 1$ (or $RP_{it} = 1$); otherwise, we assign the value of 0 to that industry. Therefore, the reference group consists of industries without policy interventions, and these two policy indicators capture the effects of ownership regulations. We also assume that there are no policy changes until a formal revision is announced in the published Catalogue. [14]

We use two proxies to measure the reduction in offshoring cost. The first is the cumulative number of national policy zones. Recent studies such as Wang (2013) show that policy zones in China promoted foreign investment and processing trade by reducing offshoring costs.[15] For the second one, we follow Limão and Venables (2001) to use infrastructure–the (log) density of highway and railway–to approximate offshoring costs reduction.

The trade data set records both the value and quantity of export at the product level (six-digit HS code), exporter locations and destinations, firm ownership types, and types of Chinese custom regimes. The firm ownership types include Chinese-owned domestic firms, joint ventures, and wholly foreign-owned firms. We use the processing export to measure the size of offshoring, and the processing export by wholly foreign-owned firms to measure FDI offshoring, and processing exports by other firms are used to measure arm's length offshoring. We also treat the high-income countries classified by World Bank as the North country for the benchmark analysis.[16] Processing exports play a major role in China's international trade, accounting for an average of 56 percent of the country's total exports from 1992 to 2008, and about 90 percent exported to high-income

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

[15]China established special economic zones for export in coastal provinces starting in the early 1980s, and later expanded into inland provinces. These policy zones include Economic and Technological Development Zone, High-Tech Development Area, Bonded Area, Export Processing Zone, and other types. Companies in these zones enjoy various advantages, including low corporate tax rate, duty-free imported inputs, absence of import and export quotas, low land costs, and non-payment of property tax in the first several years. They are also prioritized in streamlined customs clearance and 24-hour customs support. The central government authorized the establishment of national policy zones, and this process is arguably an exogenous one that is beyond the control of provincial governments. The data source is the China Development Zone Review Announcement Catalogue (NDRC, 2007).

[16]Our definition of high-income countries follows the World Bank's standard classification, including 66 countries. Taiwan is not included in the World Bank's data, although it qualifies to be a high-income region. We add Taiwan into our sample because it is an important trade partner of mainland China. For robustness check we also use all China's trade partners as the North country. Most of empirical results hold for both samples.

countries. Table 1 presents the summary statistics of processing exports.

The CUHS, conducted by China's National Bureau of Statistics (NBS), records basic conditions of urban households and provides detailed information of workers' demographic characteristics (age, gender, and marital status), employment (income, educational attainment, working experience, occupation, and sector) and geographic residence (city and province). The survey includes information on about 15,000 to 56,000 workers in a year. In this paper, we focus on annual wages of manufacturing adult workers engaging in wage employment. Wage income consists of basic wage, bonus, subsidies and other labor-related income from regular jobs. We compute the real wage by deflating annual wages to the base year (2006) using province-specific urban consumption price indices.

4 Empirical Findings

4.1 Skill Content of Offshoring

In this section, we first present evidence for the skill content difference between FDI offshoring and arm's length offshoring. Figure 5 (a) presents the evolution of average skill intensity of two types of processing exports for the period 1992-2008. The average skill intensity is defined as the weighted average of industrial skill intensity, using the industrial share of processing exports as the weights.[17] The measure of skill intensity z_i for industry i is defined as the employment share of workers with college degrees or above in total industrial employment, using the industrial employment information from Chinese National Industry Census 1995 (CNIC1995).[18] It clearly shows that FDI offshoring is more skill intensive than arm's length offshoring, and there has been

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

[18]We convert both the skill intensity measure at Chinese Standard Industrial Classification 1994 (CSIC1994) at 3 digits level and trade data based on 6 digits of Harmonized system into ISIC REV.3 at 4 digits level. Once we restrain ourselves to manufacturing sector, we cover 113 out of 127 classes in ISIC REV.3 at 4 digits level. Please see the concordance detail in Appendix F.2. We drop the most skill-intensive sector to avoid that our results are impacted by this sector, which is 75 percent higher than the second highest. As a robustness check, we use the skill intensity measure from the National Economic Census 2004 (NEC 2004). The results remain the same.

significant skill upgrading in the processing exports since 1992.

Next, we examine the distributions in skill intensity across the two types of offshoring. Figure 5(b) presents the distributions of processing exports by firm ownership types in 1992 and 2008.[19] This figure reveals two important messages. First, the distribution of FDI processing export is more skewed toward skill-intensive sectors than that of arm's length processing exports. In other words, FDI processing exports first-order stochastically dominate those of other firms. Moreover, this feature is more significant in 2008 than 1992. Second, all distributions shift toward right from 1992 to 2008, implying significant skill upgrading in the processing exports. Note this feature is also more significant for FDI processing exports.

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

The Kolmogorov-Smirnov test requires independent identical sample, while we have sampling data for 1992-2008 and they may have auto-correlations across years. Thus, we run the test year by year. Panel A in Table 2 presents the p-value for testing results in which a small number indicates rejecting the hypotheses. The two-sided test shows that it rejects the null for years 1997-2008 at 5 percent significance level but not for earlier years, and the one-sided test does not reject the null for all years in our sample. Thus, we conclude that FDI processing exports have been more skill intensive than arm's length processing export since 1997. It is reasonable that the two-sided test fails to reject the null for years before 1997, because the offshoring cost was high and foreign ownership was restricted, only a few foreign-owned firms entered. Thus, the distributions are not statistically different from each other. As the offshoring cost declined and the restrictions on foreign ownership were gradually removed, more intermediate goods were offshored through

[19] The empirical distribution $\widehat{G}^O(z)$ for $O = F, D$ is constructed as follows: $\widehat{G}^O_t(z) = \sum_i I(z_i \leq z) rs^O_{i,t}$, where $I(.)$ is the indicator function.

foreign-owned firms, and their distributional differences became statistically significant.

This two-step testing procedure can be applied to testing for skill upgrading in processing exports for each type of firms. Panel B in Table 2 shows the results for each five-year interval during 1992 and 2007. The two-sided test rejects the null at 5 percent significance level, but the one-sided test fails to reject the null for all firms in three time regimes. It implies that there is significant skill-upgrading in processing exports for all firms. However, recall the fact that processing exports by foreign-owned firms became more skill intensive than those through arm's length only after 1997. Thus, the skill upgrading must be similar for all firms initially, but later it becomes more substantial in FDI processing exports.

In the end, we calculate the contribution of FDI processing export to the total skill content in total processing exports, as the ratio of the skill content in the FDI processing exports to the skill content of the total processing export, i.e., $skshr_t^F = \sum_i z_i r_{i,t}^F / \sum_i z_i r_{i,t} = (\tilde{z}^F/\tilde{z})(\sum_i r_{i,t}^F / \sum_i r_{i,t}) = Z^F * RS_t^F$ 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 FDI processing exports. This implies that the contribution of FDI processing exports to skill content can be decomposed into two parts: the relative average skill intensity and its share in processing exports. This exercise shows that its contribution has risen from about 12 percent to about 70 percent of total skill content of processing exports, and most of them comes from the rising size of FDI processing exports. Thus, FDI becomes the major contributor of the skill content in processing exports.[20]

4.2 Offshoring and Ownership Structure

So far we have shown that FDI processing exports are more skill intensive than arm's length offshoring. Thus, the distribution of FDI processing exports has important implications for the

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

difference in regional skill demand and skill premium. Next we study the determinants of regional and industrial distribution of two types of processing exports. In particular, we test whether offshoring cost reduction and ownership liberalization increase the processing exports, particularly through FDI, as shown in our Proposition (2).

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

$$\begin{aligned} ln(R_{oijt}) &= \theta_0 + \theta_1 F_{oijt} + \rho_1 EP_{it} + \rho_2 RP_{it} + \rho_3 Cost_{jt} \\ &\quad + (\beta_1 EP_{it} + \beta_2 RP_{it} + \beta_3 Cost_{jt}) \times F_{oijt} + \theta_2' \mathbf{X} + \xi_i + \xi_j + \xi_t + \epsilon_{oijt} \end{aligned} \tag{10}$$

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

For control variables in $\mathbf{X}$, following Romalis (2004), this regression also includes the factor endowment variables (physical and human capital) interacted with industry-specific factor intensity.[21] To control for the role of institutions, we follow Nunn (2007) to include the interaction term of industry-specific contract intensity $Contr_i$ and the regional contract environment $Inst_j$.[22] To avoid the potential contemporaneous correlations between the error term and provincial variables such as infrastructure, national policy zones, skill labor endowment, and capital stock, we use one-year lagged values. For easy interpretation, all variables except indicator variables are de-meaned before we compute the interaction term. ξ_i, ξ_j and ξ_t are used to control for industry, province and year fixed effects. To control for unobserved time-varying provincial variables such as local government policies and agglomeration, we also control for province-year fixed effect as an alternative specification, at the cost of losing the estimates for the observed province time-varying variables, such as the measures of offshoring cost reduction.

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

The most important empirical findings are presented by the four interaction terms with FDI

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

[22] Following the idea of Nunn (2007), the industry-specific contract intensity is proxied by the inputs share of the relationship specific intermediates based on the Chinese input-output table (Feenstra et al., 2013). We are very grateful to Hong Ma for sharing this Nunn index with us. The measure of provincial contract environment is from the survey of doing business in 30 provincial capitals in China, published by World Bank (2008). Specifically, we use the "court cost" variable in their data, which is measured as the ratio of official costs of going through court procedures to the debt claim. Higher "court cost" indicates an inefficient, rent-seeking legal system, implying a lower probability of upholding contracts between firms. For convenience of interpretation, we construct a court efficiency measure, which equals 0.5 minus the variable court cost.

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

The second column in Table 3 presents the results with controls for the interaction terms of industry-specific factor intensities and provincial factor endowments. The positive coefficients of those interaction terms indicate the role of regional comparative advantage. Regions with more abundant skilled labor or capital exports more skill intensive or capital intensive products. Provinces with better contract environment exports more contract-intensive products, and the magnitude is also similar to the findings in (Feenstra et al., 2013).[23]

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

Table 1 shows that the shares of FDI in processing export are relatively higher in high-skill

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

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

intensive industries, particularly in the years around 2001 when China got access to WTO. Thus, next we further investigate whether the increase in exports through FDI is mainly from the high-skill intensive industries. Column 4 and 5 in Table 3 present estimation results for the specification (10) separately for high and low-skill intensive industries with the sample mean as the threshold. On the basis of the interaction terms, we find that the industrial encouragement and restriction policies exert much stronger effects on FDI processing exports relative to outsourcing processing exports in high skill intensive industries compared with low skill intensive industries. Moreover, improvements in infrastructure and the establishment of policy zones also help FDI processing exports more in high skill intensive industries. These findings are broadly consistent with model predictions.[25]

4.3 College Premium

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

The classic Mincer regression models the log real wage as a function of workers' education and years of potential labor market experience. Thus, the dependent variable for analysis, $\ln(W_{mjt})$, is the log real annual wage for individual m in province j and year t. We use college indicator (C_{mjt}) as the basic measure of skillness, and thus the coefficient of the college indicator reflects the college premium. Because of the local labor market frictions, the college premium may be different due to differential regional exposures to globalization and other factors such as skill biased technology. The augmented Mincer earning regression models the college premium as a function of factors that

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

affect the regional skill demand. Thus, we interact the college indicator with those relevant regional (provincial) variables, including the ratio of processing exports to industrial outputs, denoted as R_{jt}, and the FDI processing exports share, denoted RS^F_{jt}, and obtain the following augmented Mincer regression:[26]

$$ln(W_{mjt}) = \alpha_0 + [\alpha_{10} + \alpha_{11} R_{jt} + \alpha_{12} RS^F_{jt} + \gamma' \mathbf{V}_{jt}] \times C_{mjt} + \alpha_2' \mathbf{\Phi}_{mjt} + \delta_{jt} + \varepsilon_{mjt} \qquad (11)$$

where $\mathbf{V}_{jt}$ are other provincial variables associated with the college premium. $\mathbf{\Phi}_{mjt}$ are other personal characteristics including gender, experience, squared experience and the indicator of state owned sector. Province-year pair dummies, i.e., δ_{jt}, are used to capture the province-year differences in the determinants of wage income. Province-year cluster robust standard deviation is adopted to control for the sample dependence. Our theory suggests that regions that have more processing exports and higher share of foreign-owned firms have higher skill demand and higher college premium, thus we would expect α_{11} and α_{12} are positive.

Table 4 presents the summary statistics of household characteristics and related provincial variables. Table 5 column (1) begins with a simple Mincer regression without any interaction terms with college indicator. It shows that on average the college workers earned about 35 percent more than non-college workers, and one additional year of experience is associated with a 4.8 percent increase in real wage. In addition, female earns about 20 percent less than male, and workers in the state sector earn about 20 percent more than workers in private sectors. These results are consistent with existing literature (Ge and Yang, 2014).

Next we include the interaction terms of the college indicator with these two key variables: the ratio of processing exports to industrial output and the share of FDI processing exports. The column (2) shows that both the size of processing exports and the share of FDI processing exports are significant for the college premium, which are consistent with our theory. However, this

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

specification does not control for alternative theories of the college premium changes. The first is the Stolper-Samuelson theorem which argues that the relative wage of unskilled workers should increase as the low-skilled abundant countries export more low-skill intensive final goods. Thus, we include the ratio of ordinary exports to industrial output to capture the forces of final goods trade. Moreover, other two popular alternative theories are skill-biased technological changes (Acemoglu, 1998) and the capital-skill complementarity hypotheses (Krusell et al., 2000). We use the ratio of R&D expenditure to aggregate output to measure the skilled-biased technological changes, and capital-to-output ratio to capture capital-skill complementarity.

Table 5 column (3) presents the result with those additional controls. Our key variables, the processing exports ratio and the share of FDI processing exports, are still significantly positive. The ordinary exports ratio, the R&D expenditure ratio, and the capital-to-output ratio have the correct signs but the effects are not significant.

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

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

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

where $\widehat{lnR_{oijt}}$ is the predicted log value of processing exports from the regression (10), based on the result in column (3) of Table 3. Then we use these predicted values as the instruments for processing exports ratio and the share of FDI processing exports in the augmented Mincer regression. Those predicted values constitute legitimate instruments because the key determinants of processing exports by types, ownership liberalization policies, national policy zones and infrastructure, are plausibly not correlated with individual households' characteristics. We present the scatter plots of the actual and predicted values of processing export ratio and the share of FDI processing export in Figure F.1 in Appendix F.1, and they show significant correlations between the actual and predicted values of the variables of interest. [27]

Column (4)-(5) in Table 5 report the results using instrument variables. We use the F-test for weak instruments, and the F-test statistics in the first stage are all above the Stock-Yogo criteria of 10, rejecting the notion of weak instruments. The IV estimates for two key variables are still significant positive, and the magnitudes are also close to the OLS estimate. Based on the IV estimates in Column (5) in Table 5, one percentage point increase in the ratio of processing exports to industrial output and the share of FDI processing exports is associated with about 0.534 and 0.295 percentage point increase in the college premium (log wage differential), respectively. We also find that ordinary exports, R&D expenditure ratio, and the capital-to-output ratio played significant roles in shaping the college premium. One percentage point increase in the ratio of ordinary exports to industrial output decreases the college premium by 0.264 percentage point, which is consistent with the Stolper-Samuelson theorem. Meanwhile, one percentage point increase in the R&D ratio and capital-output ratio is associated with 1.548 and 0.025 percentage point increase in the college premium, respectively. These findings are consistent with the skill biased technological changes and capital-skill complementarity hypotheses.[28]

The college premium (log wage differential) in manufacturing sector in urban China has increased by 14.9 percent from 2000 to 2006. During this period, the ratios of processing and ordinary exports to industrial output barely changed, thus their quantitative contributions to the college premium are nil. The share of FDI processing exports, the R&D ratio, and the capital-output ratio have increased by about 25, 0.5, and 8 percents, and thus contributing about 50, 5, and 1 percents

[27] Notice this manual two-stage regression generates consistent estimates of coefficients, but their estimated standard errors are incorrect. Thus, We use non-parametric bootstrap method to correct the standard errors(Angrist and Pischke, 2008).

[28] As a robustness check, we also include the import share of equipment to capture the imported skilled biased technology, following Eaton and Kortum (2001) and Burstein et al. (2013). The results are largely unchanged.

of the rising college premium, respectively. Overall, they account for 56 percent of the total increase in the college wage premium between 2000 and 2006. Our back-of-envelope calculation implies that FDI processing exports played the most important role in raising the skill premium in manufacturing sector in urban China. This result is consistent with Feenstra and Hanson (1997) which found that the growth of FDI inflow into Mexico can account for over 50 percent of the increase in the skilled labor wage share in late 1980s.[29] Our results also suggest that the Antràs mechanism plays a more significant quantitative role than Feenstra-Hanson's channel in raising the skill premium in China.

4.4 Sensitivity Analysis

Next we conduct various sensitivity analysis on the determinants of skill premium. The first concern is the omitted ability problem which might lead to positive bias in college premium. Due to the data limitation, these well-known instruments for the college indicator and schooling years are not available in CUHS.[30] To alleviate this concern, we use the cohort whose potential college education was during the Cultural Revolution (1966-1976) for a robustness check. As the National Higher Education Entrance Examination has been abolished during the Cultural Revolution, the selection of college education in this period was more political oriented and less depended on personal ability for education and potential earning. Park et al. (2015) find that the Cultural Revolution was a great equalizer of educational access, and among city-cohorts affected during the Cultural Revolution years, children's educational attainment became much less correlated with that of their parents compared with other cohorts prior or after the Cultural Revolution. To proceed this exercise, we keep only the birth cohort during 1947 and 1957 and rerun our regression (11).

[29]Two reasons might help to explain our estimated contributions of skill biased technological changes and capital-skill complementarity are relatively smaller than their roles in the literature (e.g. (Ge and Yang, 2014)). First, our analysis only focuses on manufacturing sector where international trade plays a relatively more important role. Second, it is possible that the FDI offshoring might already capture part of skill baised technological changes (Acemoglu et al., 2015).

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

Column 1 in Table (6) shows that the two key interaction terms of college indicator with the ratio of processing exports and the share of FDI processing exports remain positive significant and their magnitudes are also close to our baseline estimates, indicating the omitted ability variable might not affect our results significantly.[31]

Second, women participation rate has been declining and the gender gap was rising during the sample period (Ge and Yang, 2014). To avoid the potential complication of the composition change of labor force, we use the male sample only, and our results are still robust as shown in Column 2 in Table (6). Third, the quality of college education might change over time. In particular, the education system itself has been reconstructed from the era of central planning economy to the market economy. It is difficult to obtain a consistent measure of educational quality for cohorts whose birth year went back to as early as 1946, as the education system has experienced significant reform in the last 60 years. We use the ratio of college teachers to college students at province level to proxy the provincial quality difference of college education. Column 3 shows that the results for our key variables are similar to the baseline estimates, and the quality of education has a negligible negative effect on the college premium.[32] Fourth, we also use the sample of processing export to all China's trade partners and achieve the similar results as shown in Column 4. This implies our results are not sensitive to the selection of high-income trade partners.

Finally, we also use years of schooling as a measure of skills, and explore the impact of the processing exports ratio and the share of FDI processing exports on the return to schooling years. We find that the effect of the size of processing exports and the share of FDI processing exports are still positively significant as shown in Table F.1. Moreover, quantitatively the magnitudes are also close to our baseline estimate of college premium if we multiply the estimated rate of return to schooling years by a factor of 4.

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

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

5 Concluding Remarks

This paper has studied a new mechanism through which the composition of offshoring from developed economies affects wage inequality in developing countries. Using data from China's processing exports, we found evidence of higher skill intensity in FDI offshoring than arm's length offshoring. When China relaxed its ownership restrictions on MNCs and lowered offshoring costs upon its accession to the WTO, more skill intensive production were shifted to the World's Factory through the affiliates of MNCs, which increased the relative demand for high-skilled labor. Our empirical analyses found that increases in FDI processing exports contributed to approximately half of the increase in college premium between 2000 and 2006 in the manufacturing sector in China.

The theory and evidence presented in this paper have far reaching implications for FDI and technology transfer to developing countries. In the globalized economy, offshoring involves complex interactions between multinational companies and the governments in the South. As shown in the China case, strategies to impose joint-ventures and technology sharing are often ineffective to attract investments and advanced technologies because MNCs would choose low-skill arm's length transactions under those 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 would have strong incentives to choose FDI offshoring with advanced products and technologies. The expansion in skill-intensive offshoring will in turn increase the returns to skill in the South and thus induce human capital investment and enhance economic growth in the long run.

References

Acemoglu, D., 1998. Why do new technologies complement skills? Directed technical change and wage inequality. Quarterly Journal of Economics 113 (4), 1055–1089.

Acemoglu, D., Gancia, G., Zilibotti, F., 2015. Offshoring and directed technical change. American Economic Journal: Macroeconomics 7 (3), 84–122.

Angrist, J. D., Pischke, J.-S., 2008. Mostly harmless econometrics: An empiricist's companion. Princeton University Press.

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

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

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

Autor, D. H., Dorn, D., Hanson, G. H., 2013. The China syndrome: Local labor market effects of import competition in the United States. American Economic Review 103 (6), 2121–68.

Burstein, A., Cravino, J., Vogel, J., 2013. Importing skill-biased technology. American Economic Journal: Macroeconomics 5 (2), 32–71.

Chen, Z., Ge, Y., Lai, H., 2011. Foreign direct investment and wage inequality: Evidence from china. World Development 39 (8), 1322 – 1332.

Costinot, A., Oldenski, L., Rauch, J., 2011. Adaptation and the boundary of multinational firms. Review of Economics and Statistics 93 (1), 298–308.

Delgado, M. A., Faris, J. C., Ruano, S., 2002. Firm productivity and export markets: a non-parametric approach. Journal of International Economics 57 (2), 397 – 422.

Dix-Carneiro, R., Kovak, B. K., 2015. Trade liberalization and the skill premium: A local labor markets approach. American Economic Review: Papers & Proceedings 105 (5), 551–57.

Eaton, J., Kortum, S., 2001. Trade in capital goods. European Economic Review 45 (7), 1195 – 1235.

Feenstra, R., 2010. Offshoring in the global economy. MIT Press.

Feenstra, R., Hanson, G., 1996. Foreign investment, outsourcing and relative wages. Feenstra, R.C., Grossman, G.M. and Irwin, D.A, eds., Political Economy of Trade Policy: Essays in Honor of Jagdish Bhagwati, MIT Press. 1996, pp.89-128.

Feenstra, R., Hanson, G., 1997. Foreign direct investment and relative wages: Evidence from Mexico's maquiladoras. Journal of International Economics 42 (3-4), 371–393.

Feenstra, R., Hanson, G., 1999. The Impact of Outsourcing and High-Technology Capital on Wages: Estimates For The United States, 1979-1990*. Quarterly Journal of Economics 114 (3), 907–940.

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

Feenstra, R. C., Hong, C., Ma, H., Spencer, B. J., 2013. Contractual versus non-contractual trade: The role of institutions in China. Journal of Economic Behavior & Organization 94 (0), 281 – 294.

Ge, S., Yang, D. T., 2014. Changes in China's wage structure. Journal of the European Economic Association 12 (2), 300–336.

Goldberg, P., Pavcnik, N., 2007. Distributional effects of globalization in developing countries. Journal of Economic Literature 45 (1), 39–82.

Gomes-Casseres, B., 1990. Firm ownership preferences and host government restrictions: An integrated approach. Journal of International Business Studies 21 (1), 1–22.

Grossman, G., Helpman, E., 2005. Outsourcing in a global economy. Review of Economic Studies 72 (1), 135.

Grossman, G., Rossi-Hansberg, E., 2008. Trading tasks: A simple theory of offshoring. American Economic Review 98 (5), 1978–1997.

Grossman, S. J., Hart, O. D., 1986. The costs and benefits of ownership: A theory of vertical and lateral integration. Journal of Political Economy 94 (4), 691–719.

Han, J., Liu, R., Zhang, J., 2012. Globalization and wage inequality: Evidence from urban China. Journal of international Economics 87 (2), 288–297.

Hart, O., Moore, J., 1990. Property rights and the nature of the firm. Journal of Political Economy 98 (6), 1119–1158.

Hsieh, C., Woo, K., 2005. The impact of outsourcing to China on Hong Kong's labor market. American Economic Review 95 (5), 1673–1687.

Hummels, D., Jørgensen, R., Munch, J., Xiang, C., 2014. The wage effects of offshoring: Evidence from danish matched worker-firm data. American Economic Review 104 (6), 1597–1629.

Hummels, D., Munch, J., Xiang, C., 2016. Offshoring and labor markets. National Bureau of Economic Research Working Paper Series, 22041.

Javorcik, B., 2004. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. American Economic Review 94 (3), 605–627.

Johnson, R. C., Noguera, G., 2012. Accounting for intermediates: Production sharing and trade in value added. Journal of International Economics 86 (2), 224 – 236.

Kalinova, B., Palerm, A., Thomsen, S., 2010. OECD's FDI restrictiveness index: 2010 update. OECD Working Papers on International Investment.

Kobrin, S., 1987. Testing the bargaining hypothesis in the manufacturing sector in developing countries. International Organization 41 (4), 609–638.

Krusell, P., Ohanian, L., Ríos-Rull, J., Violante, G., 2000. Capital-skill complementarity and inequality: A macroeconomic analysis. Econometrica 68 (5), 1029–1053.

Limão, N., Venables, A. J., 2001. Infrastructure, geographical disadvantage, transport costs, and trade. World Bank Economic Review 15 (3), 451–479.

National Development and Reform Commission (NDRC), 2007. China development zone review announcement catalogue.

Nunn, N., 2007. Relationship-specificity, incomplete contracts, and the pattern of trade. Quarterly Journal of Economics 122 (2), 569–600.

Park, A., Giles, J., Wang, M., 2015. The great proletarian Cultural Revolution, disruptions to education, and the returns to schooling in urban China. IZA Discussion Papers, 8930.

Qian, Y., Bai, C., Hsieh, C., 2007. The return to capital in China. Brookings Papers on Economic Activity 2006 (2), 61–101.

Romalis, J., 2004. Factor proportions and the structure of commodity trade. American Economic Review 94 (1), 67–97.

Sheng, L., Yang, D. T., 2016. Expanding export variety: The role of institutional reforms in developing countries. Journal of Development Economics 118, 45 – 58.

Silva, J. S., Tenreyro, S., 2006. The log of gravity. Review of Economics and statistics 88 (4), 641–658.

Tombe, T., Zhu, X., 2015. Trade, migration and productivity: A quantitative analysis of China. Working paper.

UNCTAD, 2006. Measuring restrictions on FDI in services in developing countries and transition economies. United Nations Conference on Trade and Development.

United Nations Conference on Trade and Development (UNCTAD), 1999. World Investment Report: Foreign Direct Investment and the Challenge of Development. New York and Geneva: United Nations.

Wang, J., 2013. The economic impact of special economic zones: Evidence from Chinese municipalities. Journal of Development Economics 101 (0), 133 – 147.

World Bank, 2008. Doing Business in China. Available at: www.doingbusiness.org/china.

Table 1: Summary Statistics of China's Processing Exports

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

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

Table 2: The Kolmogorov-Smirnov Test for Stochastic Dominance

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

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

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

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

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

Table 3: Determinants of China's Processing Exports

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

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

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

Table 4: Summary Statistics

Panel A: Households Characteristics					
Variables	Obs	Mean	Std. Dev.	Min	Max
Ln(wage)	156,658	8.86	0.76	2.09	12.43
College	156,658	0.16	0.37	0	1
Schooling years	156,658	11.17	2.48	0	18
Age	156,658	39.35	8.94	16	60
Experience	156,658	21.75	9.29	0	44
Sex	156,658	0.45	0.50	0	1
State sector indicator	156,658	0.70	0.46	0	1
Panel B: Provincial variables					
Ratio of processing exports to industrial output	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 ratio	435	0.01	0.01	0.00	0.09
K/Y 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
Share of persons with college degree in population aged above 5	435	0.04	0.04	0.00	0.29

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

	OLS			IV[a]	
Independent variables	(1)	(2)	(3)	(4)	(5)
College indicator	0.350***	0.251***	0.214***	0.256***	0.221***
	(0.009)	(0.011)	(0.031)	(0.010)	(0.022)
College indicator interaction terms					
College × Processing exports ratio		0.440***	0.492***	0.489***	0.534***
		(0.140)	(0.145)	(0.122)	(0.132)
College × Share of FDI processing exports		0.315***	0.316***	0.284***	0.295***
		(0.043)	(0.045)	(0.050)	(0.049)
College × Ordinary exports ratio			-0.202		-0.264*
			(0.224)		(0.137)
College × R&D ratio			0.904		1.548***
			(0.869)		(0.475)
College $\times K/Y$			0.029		0.025*
			(0.024)		(0.015)
Individual characteristics					
Experience	0.048***	0.048***	0.048***	0.047***	0.047***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Experience square	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Sex	-0.202***	-0.202***	-0.202***	-0.208***	-0.208***
	(0.006)	(0.006)	(0.006)	(0.003)	(0.003)
State owned sector	0.195***	0.197***	0.196***	0.194***	0.194***
	(0.010)	(0.010)	(0.010)	(0.004)	(0.004)
Prov-Year FE	YES	YES	YES	YES	YES
First stage F-stat				> 190.41	> 237.72
N	156,658	156,658	155,905	143,010	143,010
R^2	0.366	0.368	0.369	0.297	0.303

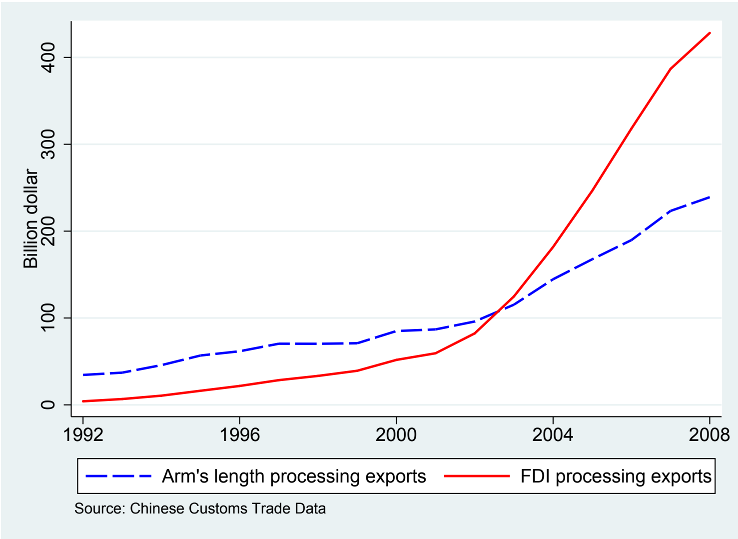
Note: the dependent variable is log annual wage income. Province-year cluster robust standard errors are in parentheses for OLS regression. *, **, and *** indicate significance at the 10,5, and 1 percent levels.

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

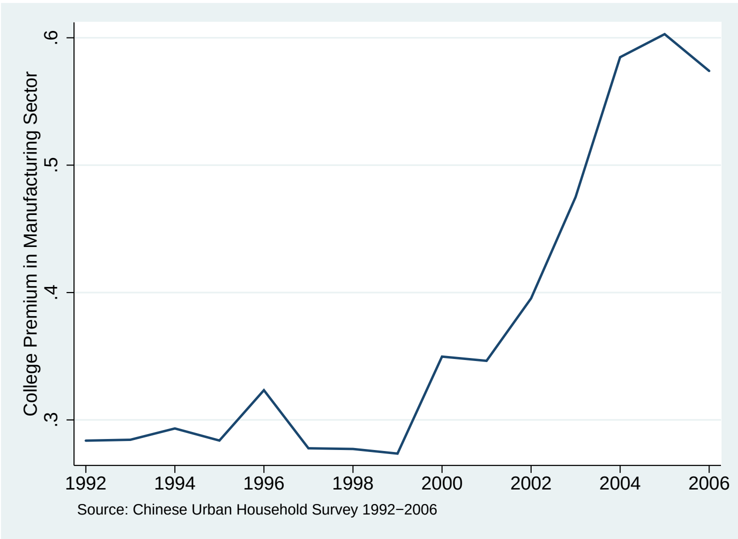
Table 6: Robustness Analysis on the College Premium

	Cultural Revolution Cohort only	Male only	Quality of Coll Education	All Trade Partners
	(1)	(2)	(3)	(4)
College indicator	0.133***	0.187***	0.240***	0.219***
	(0.036)	(0.026)	(0.022)	(0.019)
College indicator interaction terms				
College × Processing exports ratio	0.348*	0.440***	0.606***	0.482***
	(0.186)	(0.132)	(0.146)	(0.144)
College × Share of FDI processing exports	0.301***	0.333***	0.292***	0.285***
	(0.076)	(0.054)	(0.050)	(0.058)
College × Ordinary exports ratio	-0.382	-0.479**	-0.317**	-0.153
	(0.254)	(0.147)	(0.146)	(0.206)
College × R&D ratio	0.216	1.794**	1.562***	1.226***
	(0.817)	(0.555)	(0.486)	(0.488)
College $\times K/Y$	0.056**	0.034*	0.015	0.024*
	(0.025)	(0.018)	(0.015)	(0.013)
College × Teacher-student ratio			-0.005***	
			(0.002)	
Individual characteristics				
Experience	0.039***	0.052***	0.047***	0.047***
	(0.005)	(0.001)	(0.001)	(0.001)
Experience square	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Sex	-0.217***		-0.209***	-0.209***
	(0.005)		(0.003)	(0.003)
State owned sector	0.243***	0.151***	0.192***	0.194***
	(0.006)	(0.005)	(0.004)	(0.004)
Prov-Year FE	YES	YES	YES	YES
First stage F-stat	> 271.72	> 248.29	> 236.24	> 177.48
N	51,775	79,086	137,316	143,010
R^2	0.296	0.287	0.300	0.303

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



(a) Ownership Structural Change in Processing Exports



(b) College Premium in the Manufacturing Sector

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

Figure 1: Processing Exports and College Premium in China

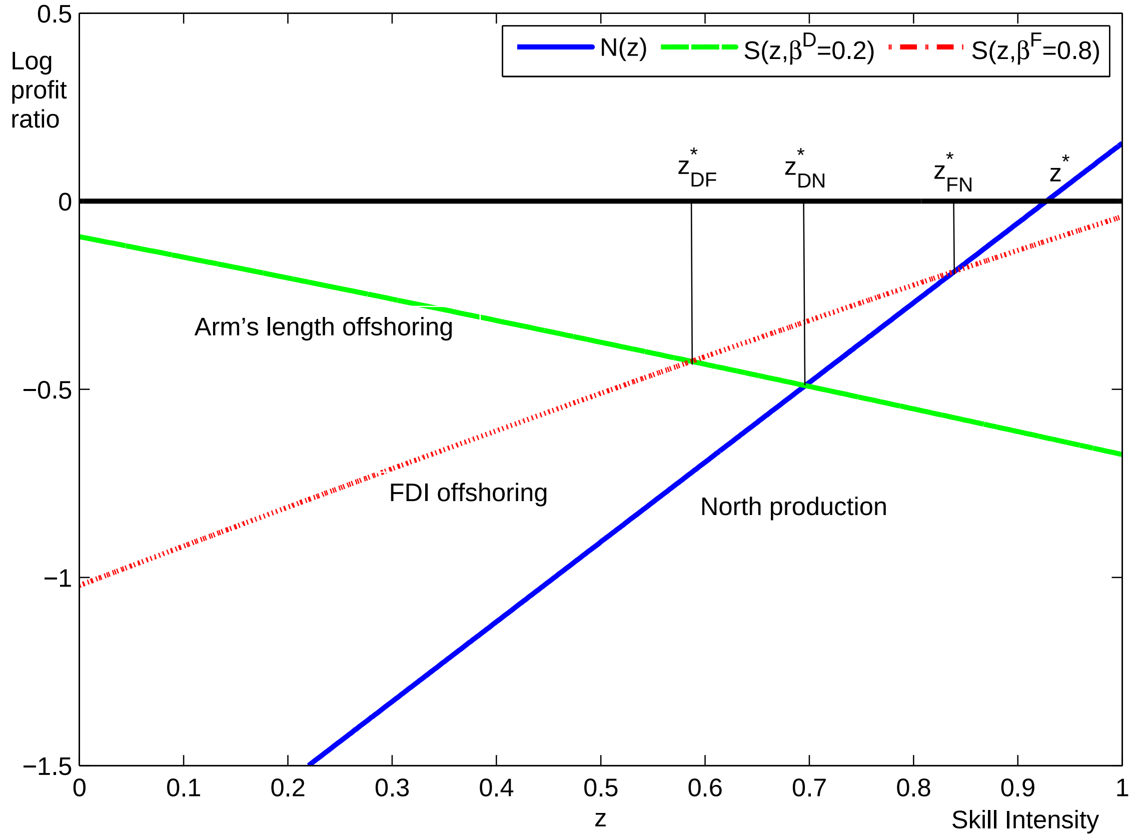


Figure 2: Offshoring, Optimal Ownership and Skill Intensity of Intermediate Goods

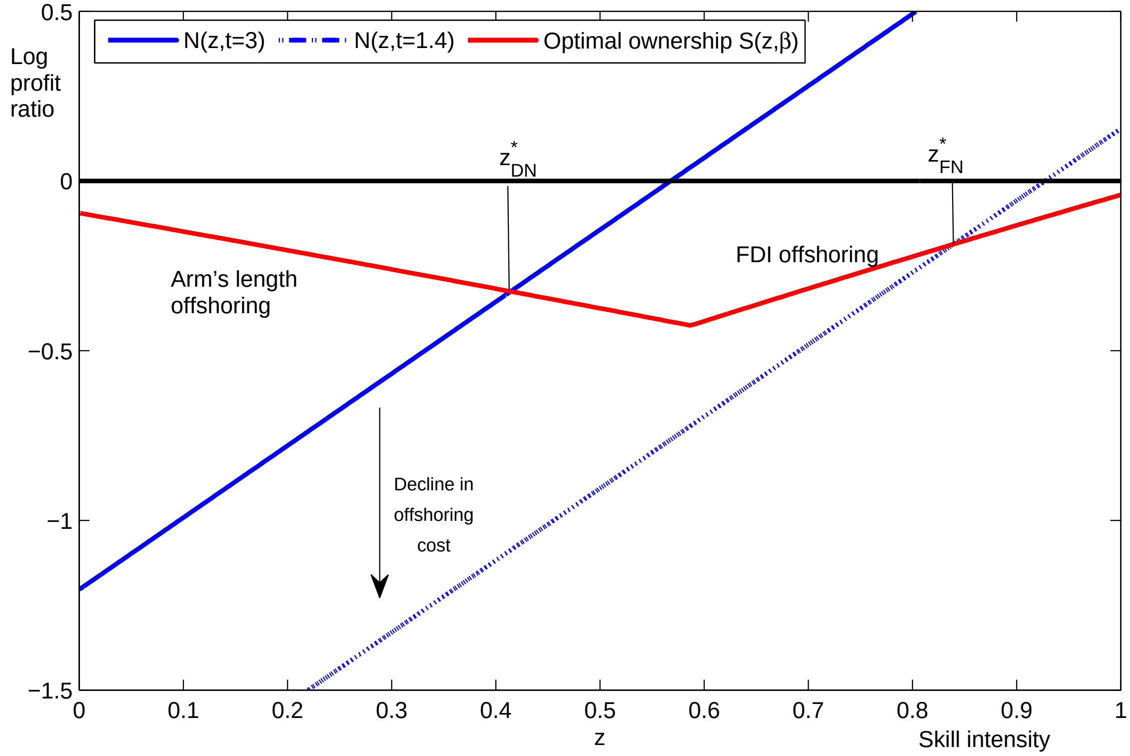


Figure 3: Offshoring Cost Reduction and Skill Intensity of Intermediate Goods

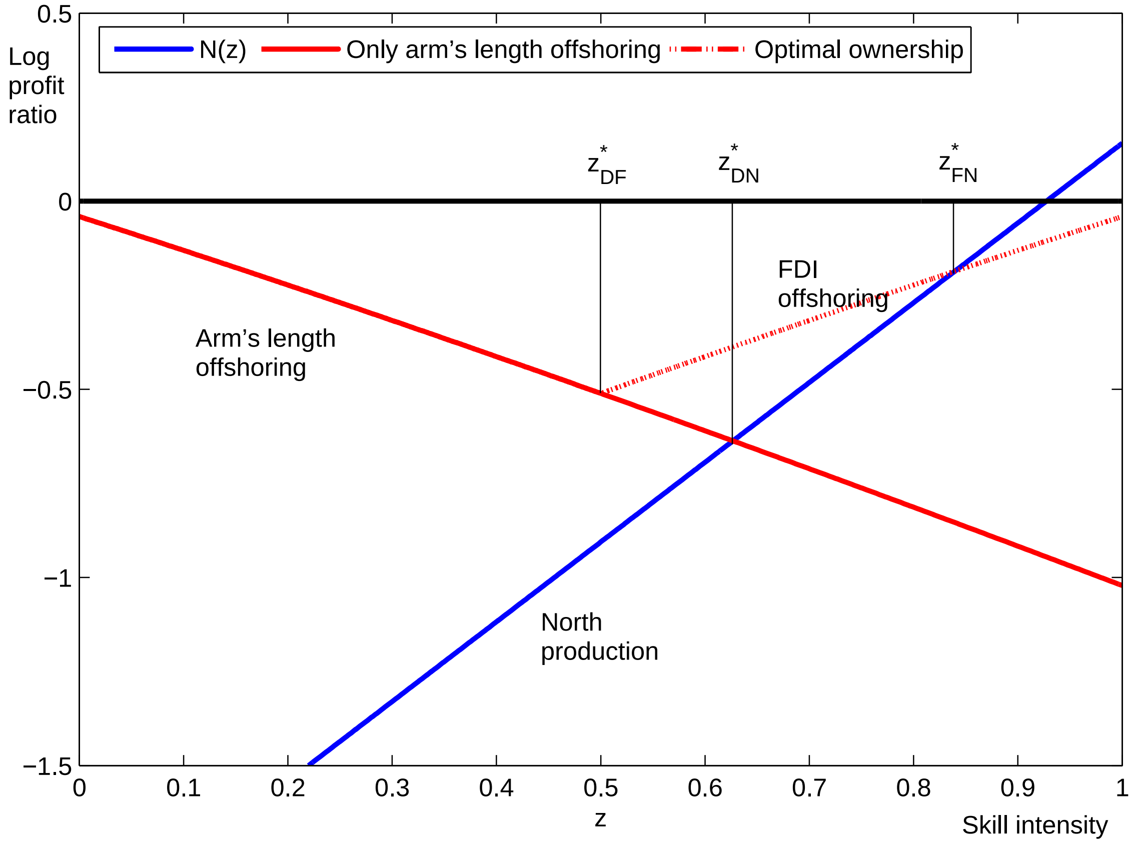
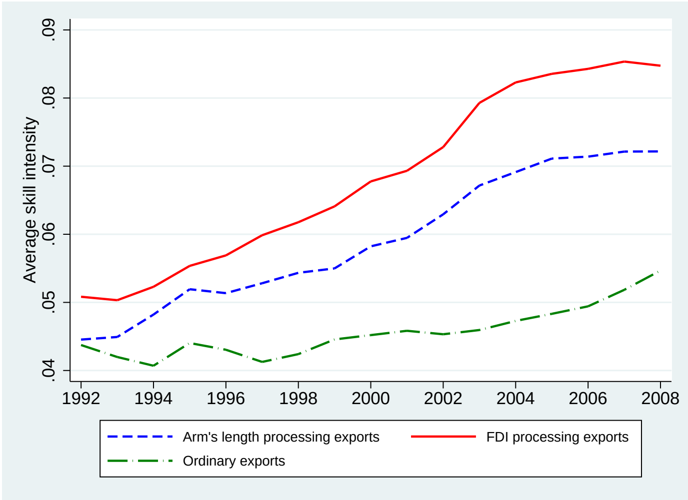


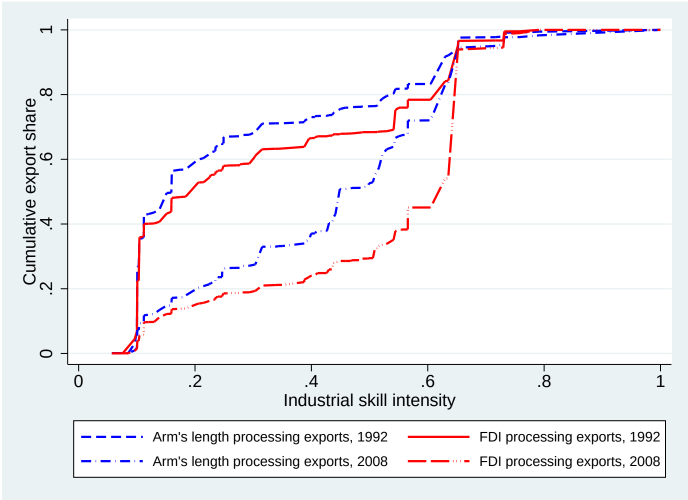
Figure 4: Ownership liberalization, Offshoring and Skill Intensity of Intermediate Goods

Figure 5: Skill Difference of Processing Exports

(a) Average Skill Intensity



(b) The Cumulative Distributions



Note: The average skill intensity is measured as the weighted average of industrial skill intensity, with industrial export shares as the weights, where the skill intensity is measured by the share of college workers within each industry using the 1995 Chinese National Industry Census.

Appendices

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

and

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

Because $S(z, \beta)$ is continuous and strictly concave in a compact set of $\beta \in [0, 1]$, there must be a unique maximizer $\beta^*(z)$ for a given value of z, according to the maximum theory. Moreover, by the Topkis's theorem, the Supermodularity implies $\beta^*(z)$ increases in z. Here we show it by using the implicit function theory. The first order condition for β is $S_\beta(\beta^*(z), z) = 0$ for an inner solution, differentiating the first order condition, with respect to z and using the implicit function theorem, we find that $\frac{\partial \beta^*(z)}{\partial z} = -\frac{S_{\beta z}(\beta^*(z),z)}{S_{\beta\beta}(\beta^*(z),z)} > 0$. For corner solution, we have $\beta^*(0) = 0$ and $\beta^*(1) = 1$, so our statement of $\beta^*(z)$ still holds.

B Proof for lemma 1

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

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

Corollary 2

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

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

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

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

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

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

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

C Proof of Proposition 1

First we define

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

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

Corollary 3

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

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

Proof. $\lim_{z\to 0} B(z,\beta,t) < 0$ holds only if the term in the bracket is negative, which is true under the Assumption 1(2). Moreover,

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

due to the facts that $t > \omega_h$ and the term in the bracket decreases in β and has a minimum at zero. To show $B_z(\beta,z,t) > 0$, we only need to show

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

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

D Proof for Proposition 2

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

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

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

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

where $\widetilde{R}(z,\beta) = R(z,\beta)/(\frac{1}{t})^{\alpha/(1-\alpha)}$ is not dependent on the offshoring cost t. Now the offshoring cost t affects the revenue share of foreign firms only through the extensive margin, i.e. cutoff $z^*_{FN}(t)$. It is easy to show that the share of foreign firms increases as $z^*_{FN}(t)$, and we know $z^*_{FN}(t)$ increases as the offshoring cost t decreases. Thus a reduction in the offshoring cost increases the FDI offshoring.

E Proof of Proposition 4

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

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

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

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

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

We can show

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

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

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

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

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

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

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

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

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

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

F Empirical Appendix

F.1 Augmented Mincer Wage Regression

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

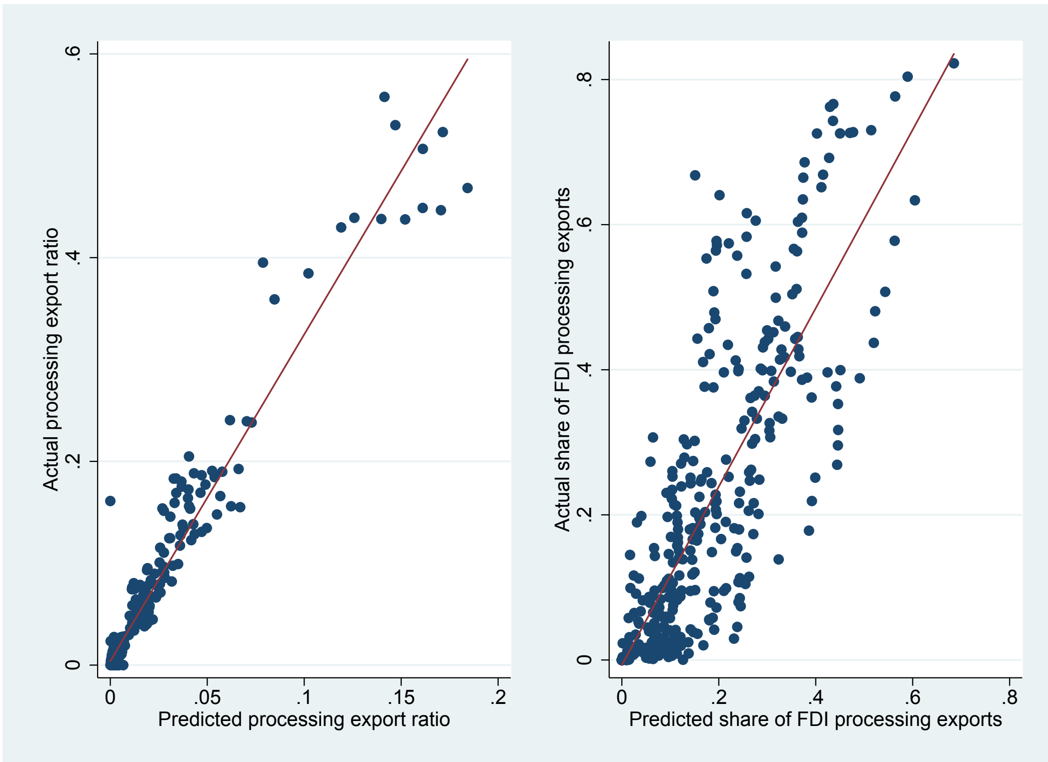


Figure F.1: Scatter Plot for First Stage Regression

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

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

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

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

F.2 Concordance

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

F.3 Provincial variables

Table F.2: Variable description

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