Task Offshoring and Organizational Form: Theory and Evidence from China*

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Abstract

Between 1997 and 2008, Chinese offshoring within multinationals (intrafirm offshoring) increased much more rapidly than offshoring through subcontracting (arm's length offshoring). This development in the organizational form of Chinese offshoring presents a puzzle, since it runs contrary to the pattern predicted by existing contract theory based models. To explain recent trends in Chinese offshoring, this paper incorporates Cremer-Garicano-Prat communication costs in Grossman-Rossi-Hansberg's (2008) model of offshoring. In particular, I develop a model in which foreign subsidiaries of multinationals benefit from lower communication costs when they perform offshored tasks, but must pay an efficiency wage premium compared with arm's length subcontractors. The model predicts that reductions in offshoring costs lead to a larger increase of the intrafirm offshoring share for industries that are more communication-intensive. To test this theoretical hypothesis, I examine how reductions in offshoring costs that are due to the establishment of export processing zones affect the organization of Chinese offshoring. I find strong evidence in support of the model's prediction: while offshoring cost reductions have an insignificant effect on the intrafirm offshoring share for the least communication-intensive industries, similar reductions in offshoring costs are associated with an 8 percentage point increase in the intrafirm offshoring share for the most communication-intensive industries.

JEL: F10, F16, F23, L22, L24

Keywords: Task Offshoring, Heterogeneous Offshoring Cost, Organizational Form, Export Processing Zones

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1 Introduction

The rapid growth of offshoring has become a dominant feature of the international economy.[1] Feenstra and Hanson (1996) find that the share of imported intermediates increased from 5.3% of total U.S. intermediate purchases in 1972 to 11.6% in 1990. Hummels, Ishii, and Yi (2001) also note that the share of imported inputs embodied in goods that are exported increased from 16.5% in 1970 to 21% in 1990 in 14 countries. Between 1997 and 2002, export processing accounted for 55.6% of China's total exports (Feenstra and Hanson 2005).[2]

Offshoring takes two possible organizational forms: offshoring within multinationals (intrafirm offshoring) and offshoring through subcontracting (arm's length offshoring).[3] More specifically, if a firm chooses to be vertically integrated and produces intermediate inputs by a foreign subsidiary, it engages in intrafirm offshoring. If it buys customized components from an arm's length supplier abroad, it engages in arm's length offshoring. However, the relative importance of intrafirm offshoring compared with arm's length offshoring remains largely unknown. More importantly, how the relative prevalence of different organizational forms changes over time is unknown at this point in time.

This paper addresses this issue, studying how factors affect the relative prevalence of different organizational forms using a task-trading framework. There are two main innovations in my theoretical model. First, in contrast to the contract-based approach of modeling organizational forms, this paper provides another mechanism in which firms choose different organizational forms based on the trade-off between communication costs and efficiency wages. Second, organizational form choice is incorporated in a task-trading framework, in which firms choose *different* organizational forms for *different* tasks. The model is able to explain the relatively faster growth of intrafirm offshoring observed in China, which runs contrary to the pattern predicted by existing contract-based theory.

The paper provides the first empirical study examining the time-series changes in different offshoring organizational forms. It shows that reductions in offshoring costs have sharply

[1] Following Grossman and Rossi-Hansberg (2008), "offshoring" means the performance of tasks in a country different from where a firm's headquarters is located.

[2] Export processing is an arrangement in which a processing factory converts intermediate inputs into finished goods and then exports the final output(Feenstra and Hanson 2005). The intermediate inputs might be purchased by the factory itself or provided by the foreign partner of the processing factory.

[3] Without causing confusion, hereafter I use "MNC", "foreign subsidiaries of multinationals" and "intrafirm offshoring" interchangeably.

different impacts on the relative prevalence of intrafirm offshoring in industries with different communication-intensities. In order to control for the endogeneity issue, the empirical study takes advantage of information on the establishment of special policy zones in China, which provides arguably exogenous shocks to offshoring costs.

Experience from China shows that intrafirm offshoring increased much more rapidly than arm's length offshoring from 1992 to 2008, as shown in Figure 1.[4] The annual growth rate of the export value of intrafirm offshoring is 33.7% while that of arm's length offshoring is only 12.7%. Moreover, this faster growth of intrafirm offshoring is not a recent phenomenon. As early as 1993, the growth rate of export value via intrafirm offshoring was around 20% greater than that of arm's length offshoring, as shown in Figure 2.

The existing literature on the organizational form of offshoring greatly enriches our understanding of factors that affect firms' organizational form choice. However, it is not very helpful in explaining this development in the organizational form of Chinese offshoring. Only in recent years have trade theorists started to bring modern theories of the firm into trade models to study choices of organizational form. Building on Grossman and Helpman (2002), Antràs (2003) uses property-rights theory to study the choice of organizational form. Antràs and Helpman (2004) further incorporate heterogeneous firms to study the impact of productivity on organizational form choice. They show that reductions in offshoring costs or labor costs in the offshoring destination country induce reorganizations that favor arm's length offshoring. This prediction runs contrary to the recent trends in offshoring observed in China.

Other models based on contract theory make similar predictions. For example, Grossman and Helpman (2004) apply the incentive-systems framework to managerial compensation in global production. They show that the effect of reductions in offshoring costs on the relative prevalence of different organizational forms is ambiguous. If the firms that conduct arm's length offshoring are those with highest productivity, then trade liberalization tends to favor intrafirm offshoring. In contrast, if the firms that conduct arm's length offshoring are those with the lowest productivity, trade liberalization favors arm's length offshoring. Arguably, China's export processing trade is closer to the latter case in the sense that arm's length

[4] Processing trade conducted by Wholly-Foreign-Owned firms is viewed as intrafirm offshoring and processing trade conducted by all other types of firms is viewed as arm's length offshoring. It would be ideal if the data indicate the relation between the processing factory and the buyer of the finished goods. Unfortunately, this information is not available.

suppliers typically have lower productivity than multinational firms (Blonigen and Ma 2007).

One important limitation of these studies is that there is no task heterogeneity. In these studies typically only one intermediate imput is offshored. However, in practice, many different tasks and intermediate inputs are offshored. Furthermore, tasks differ in how difficult they are to offshore. "Routineness", as identified in Autor, Levy, and Murnane (2003), "codifiability", as identified in Leamer and Storper (2001), and "impersonality", as identified in Blinder (2006), all might affect the "offshorability" of the task.[5] Tasks thus may be performed at the headquarters or may be offshored depending on their offshoring costs.

Grossman and Rossi-Hansberg (2008) provide the first task-trading framework that recognizes heterogeneity in offshoring costs, and they use the model to study the welfare implications of task offshoring. This new conceptualization of offshoring better captures firms' offshoring activities. Firms progressively offshore more and more tasks to developing countries. Figure 3 shows that the value-added share of processing exports in China has increased continuously from 1992 to 2008. Blonigen and Ma (2007) also provide evidence that increasingly more sophisticated products were offshored to China over time.

This paper shows that this new conceptualization of task trading is also essential to understanding the relatively faster growth of intrafirm offshoring in China. In this paper, I first develop a simple model of task offshoring based on Grossman and Rossi-Hansberg (2008), incorporating different organizational forms. In this model a continuum of tasks needs to be performed to produce goods. Firms are motivated to offshore tasks and choose the organizational form for each offshored task based on the prospect for factor-cost savings. Some tasks are offshored because it is cheaper to perform them abroad. For the offshored tasks, firms face a trade-off in choosing the organizational form for each task. Foreign subsidiaries of multinationals benefit from lower communication costs when they perform offshored tasks, but must pay an efficiency wage premium compared with arm's length suppliers to prevent their workers from shirking. The set of tasks performed in different organizational forms and in different locations are determined endogenously so that the cost of the marginal task is equalized across organizational forms or locations.

The essential trade-off involves communication costs versus efficiency wages. I model com-

[5]For a comprehensive study of "offshorability", see Blinder and Krueger (2009).

munication costs based on Cremer, Garicano, and Prat (2007). Specifically, workers encounter problems when they perform tasks and communication is required to solve these problems. Communication in intrafirm offshoring is more effective than in arm's length offshoring.[6] Efficiency wages stem from imperfect international monitoring. The ability to monitor workers' efforts is assumed to depend on proximity (Grossman and Helpman 2004). For intrafirm offshoring, shirking can only be partly detected due to remote monitoring. However, monitoring of arm's length suppliers is perfect due to onsite monitoring by their owners. Thus foreign subsidiaries of multinationals must pay an efficiency wage premium to prevent their workers from shirking.[7]

My model sheds light on the impacts of organizational form choice on the welfare implication of offshoring. I show that the productivity effect identified in Grossman and Rossi-Hansberg (2008) can be decomposed into three subeffects. First, reductions in offshoring costs directly contribute to the productivity effect, which I call the "direct cost savings effect". Second, the reductions in offshoring costs decrease the efficiency wages paid for intrafirm offshoring and consequently contribute further to the productivity effect. I call this subeffect the "indirect cost savings effect" since it works through the channel of the labor market under intrafirm offshoring. There is a third subeffect, which I call the "MNC expansion effect," that may partially offset the productivity effects achieved by the first two subeffects. Since firms produce a larger quantity of goods and offshore more tasks as offshoring becomes cheaper, such expansions in production and offshoring increase the labor demanded by the MNCs. Consequently, the efficiency wages paid by MNCs are higher and this partially offsets the productivity effects.

Notice that the indirect cost savings effect and the MNC expansion effect both work through the labor market under intrafirm offshoring. My model thus identifies the important impacts of the organizational form choice on the productivity effect. The labor market for intrafirm offshoring is a segmented labor market and the subsidiaries of multinationals often

[6] For example, it is easier to arrange a face-to-face meeting within the boundary of firm than between armslength parties.

[7] That imperfect monitoring leads to higher efficiency wage is well known. See, for example, Matusz (1996) and Blanchard and Fischer (1989). There is also plenty of empirical evidence showing that foreign invested firms pay higher wages than domestic firms, such as Aitken, Harrison, and Lipsey (1996). It is also shown that workers moving from a domestic to a foreign firm experience an increase in wages in Andrews, Bellmann, Schank, and Upward (2007).

pay higher wages than the foreign indigenous firms.[8] With reductions in offshoring costs, the unit labor cost of performing each task becomes lower while the range of tasks to be performed in these subsidiaries grows larger. Since labor demand for these subsidiaries is positively related to the efficiency wage, the overall effect on labor demand determines whether productivity increases or not. If the labor demanded by these subsidiaries increases, then the efficiency wages paid by the subsidiaries will be higher and the productivity effect lower. On the other hand, if labor demand is reduced due to reductions in offshoring costs, then efficiency wages will be lower. This would generate extra cost savings for intrafirm offshoring and the productivity effect would be larger.

Most importantly, the model enables us to analyze the effect of reductions in offshoring costs on the relative prevalence of different organizational forms. I show that the relative prevalence depends on the curvature of the offshoring cost function and the communication intensity of the industry. If the offshoring cost function is steep, falling offshoring costs favor intrafirm offshoring. If the industry is communication intensive, lower offshoring costs also lead to a larger share of intrafirm offshoring.

The intuition is straightforward. If the offshoring cost function is steep, only a few new tasks will be offshored even when there is a big fall in offshoring costs. The big fall in offshoring costs leads to a large drop in labor demand for intrafirm offshoring. On the other hand, the fact that there are only a few newly offshored tasks means there is only a small increase in labor demand for intrafirm offshoring. The net effect is a fall in labor demand for intrafirm offshoring and a lower efficiency wage. This consequently makes intrafirm offshoring more attractive relative to arm's length offshoring and intrafirm offshoring becomes more prevalent.

Similarly, if the industry is more communication intensive, the difference in communication efficiency between arm's length offshoring and intrafirm offshoring is larger. Transferring tasks from intrafirm offshoring to arm's length offshoring is more difficult. Thus, although falling offshoring costs cause new tasks to be offshored from home to foreign subsidiaries, far fewer tasks are shifted from intrafirm offshoring to arm's length offshoring. This again makes

[8] The OECD Employment Outlook (2008, p289) states that "labour markets may be segmented between foreign and domestic firms because foreign-owned firms tend to provide better working conditions, in order to limit worker turnover or because of institutional differences such as compliance with labour laws or bargaining strength vis-a-vis trade unions."

intrafirm offshoring more prevalent.

The model thus predicts that reductions in offshoring costs lead to a larger increase in the intrafirm offshoring share for industries that are more communication-intensive. This prediction is consistent with the recent trends in offshoring in China. First, the overall relatively faster growth of intrafirm offshoring in China may be a result of reductions in offshoring costs. A simple cross-section analysis suggests that the share of intrafirm offshoring is indeed positively correlated with reductions in offshoring costs. Figure 4 shows that in some special policy zones in China lower offshoring costs are associated with larger shares of intrafirm offshoring.[9]

Second, different industries do respond differently to reductions in offshoring costs in China, depending on their communication intensities. Figure 5 shows that, for industries that are less communication intensive, reductions in offshoring costs that are due to the establishment of export processing zones (EPZs) tend to decrease the intrafirm offshoring share. However, for industries that are more communication intensive, similar reductions in offshoring costs tend to increase the intrafirm offshoring share.

Compared with studies based on contract theory, the predictions of my model are in the opposite direction. Two key factors are important in leading to this difference. First, a task trading framework allows firms to choose different organizational forms for different tasks. The prevalence of different organizational forms is determined by the range of tasks performed by each type of organizational form by the *same* firm. However, studies based on contract theory typically assume only one task to be offshored and the prevalence of different organizational forms is determined by the *number* of firms choosing different organizational forms. Second, my model provides an alternative reason for why firms want to choose different organizational forms. Specifically, firms may choose intrafirm offshoring to save on communication costs. In contrast, in studies based on contract theory firms choose intrafirm offshoring in order to avoid incomplete-contracting related costs.

The empirical analysis in this paper tests the theoretical prediction that reductions in

[9] The special policy zones in the figure are Economic and Technology Development Areas in China in 2007. The offshoring cost index is constructed as the sum of indexes of the cumulative investment in infrastructure, the capability of water, steam and gas supply, whether the administrative institution passes *ISO* 9001 certification, whether the zone has authorities to approve provincial level foreign investment projects, whether the administrative management is efficient, and whether the zone has patent protection offices. The larger the index, the lower the offshoring cost.

offshoring costs lead to a larger increase in the intrafirm offshoring share for industries that are more communication-intensive. I examine how reductions in offshoring costs that are due to the establishment of export processing zones affect the organization of Chinese offshoring. The data cover China's export processing for the period of 1997-2007. Previewing the empirical results, I find strong evidence in support of the model's prediction: while offshoring cost reductions have an insignificant effect on the intrafirm offshoring share in the least communication-intensive industries, similar reductions in offshoring costs are associated with an eight percentage point increase in the intrafirm offshoring share for the most communication-intensive industries. These results are robust to different specifications and different measures.

My findings are relevant to several bodies of literature. Despite intense theoretical interest in offshoring organizational form, there is little empirical work on this topic. Feenstra and Hanson (2005) study factory ownership and input control in China's export processing trade, but their main focus is on whether the offshoring firm both owns the processing factory and has control of the processing activities. My work instead focuses on how offshoring costs affect firms' choice of different organizational forms. A second body of literature to which my work relates is the work on "task trading". Among others, Grossman and Rossi-Hansberg (2008) propose this "new paradigm";[10] Costinot, Oldenski, and Rauch (2009) show that complex tasks tend to be offshored in the form of intrafirm offshoring; and Keller and Yeaple (2008) study the location choice of task trading. I extend the literature by studying the organizational form choice of task trading. Moreover, based on Cremer, Garicano, and Prat (2007), I make the offshoring costs endogeneous, which are typically assumed exogenous in the literature.

The remainder of this paper is organized as follows. Section 2 constructs a model introducing different organizational forms and studies the effects of reductions in offshoring costs on factor prices and the relative prevalence of different organizational forms. Section 3 tests the theoretical hypothesis that reductions in offshoring costs lead to a larger increase in the intrafirm offshoring share for industries that are more communication intensive. Section 4 concludes.

[10] Feenstra and Hanson (1996) use a related approach to study an economy in which final goods are assembled using a continuum of intermediate inputs. Different from Grossman and Rossi-Hansberg (2008), they assume that the intermediate inputs are costlessly traded.

2 The Model

Following Grossman and Rossi-Hansberg (2008), there are two countries, home and foreign. Each country has two industries, X and Y. The production of one unit of either good involves a continuum of L-tasks, which only use low-skilled labor, and a continuum of H-tasks, which only use high-skilled labor. The measure of tasks are normalized such that to produce one unit of each good, each task must be performed once. It is further assumed that to produce a good at home, completion of tasks within each type require the same amount of factor.

The industries may differ in their factor intensities, which means, for example, that a typical L-task in one industry may use a greater input of domestic low-skilled labor than an L-task in the other industry. Without loss of generality, industry X is assumed to be relatively more skill intensive. If for industry j, $j \in \{X, Y\}$, a_{Lj} units of low-skilled labor and a_{Hj} units of high-skilled labor are used to perform L-tasks and H-tasks to produce one unit of output j, the assumption implies that $a_{Hx}/a_{Lx} > a_{Hy}/a_{Ly}$. The production technology is constant return to scale.

Firms can undertake tasks at home or abroad. For simplicity, I assume firms only offshore L-tasks.[11] Tasks can be performed offshore either in the form of intrafirm offshoring or in the form of arm's length offshoring. The two forms of organization are economically distinct. First, intrafirm offshoring has lower communication costs than arm's length offshoring. Second, MNCs pay higher efficiency wages than arm's length suppliers. The trade-off between communication costs and wage costs shapes firms' equilibrium organizational form choices for each task.

2.1 Communication Cost

Tasks differ in their complexity. Workers encounter a larger range of problems when they perform more complicated tasks. Tasks are indexed by i, $i \in [0, 1]$, indicating the complexity levels, and more specifically, the range of problems workers might encounter. A task with index i means that workers would encounter problems that are drawn from a uniform distribution with a support $[0, i]$.

[11] Offshoring of H-tasks delivers similar results. In this case, the high-skilled labor wage, rather than low-skilled labor wage, is affected. The effects on relative prevalence of different organizational forms are identical. Although it is not necessary for the small country case analysis, I include two factors and two goods in the model so that the model is general enough to analyze the large country case.

The only type of offshoring cost considered here, the communication cost, arises when problems need to be solved abroad, since communication is not costless. To solve the problem encountered, workers in the foreign country must communicate with home headquarters. Due to bounded rationality, workers can only incompletely describe the problem using a limited number, K, of "words", as in Cremer, Garicano, and Prat (2007). After hearing a word, the engineer in the headquarters knows that the problem is in an interval defined by that word and she needs to diagnosis the exact problem, which lies somewhere within that interval. The diagnosis cost is assumed to be a function, $t(z)$, of the length of the interval, z. It is continuously differentiable and satisfies $t(0) = 1$, $t^{'}(z) > 0$ and $t^{''}(z) > 0$.[12]

The number of words that can be used in communication is exogenous.[13] However, how to code these words to refer to intervals is an optimal choice. It can be shown that the optimal code system, i.e. a system defining the mapping of words into intervals, is to divide the range of potential problems into equal-length intervals.[14]

The communication cost for using a K-word code system to solve problems related to a task indexed by i is endogenously determined. For task i, the optimal length of each interval is i/K. The probability of using each word is $1/K$ and there are K such intervals. Thus the expected communication cost for the task i is then $\beta t\left(\frac{i}{K}\right)$, where $\beta > 1$, representing the communication technology.[15]

After the engineer in the headquarters diagnoses the problem and returns the solution to the worker, the worker can perform the task with no further problems. Assuming the production technology, a_{Lj}, is perfectly transferable to foreign partners regardless of the organizational form,[16] a firm that chooses a_{Lj} for L-tasks at home needs to employ $\beta t\left(\frac{i}{K}\right) a_{Lj}$ units of foreign labor to perform the same task offshore, for a given number of words, K.

Intrafirm offshoring and arm's length offshoring differ in communication efficiency.[17] For

[12] Some further assumptions about $t(z)$ will be specified later.

[13] The number of words could potentially be endogenized by assuming that words are expensive to obtain.

[14] This is proved in Cremer, Garicano, and Prat (2007) appendix B.

[15] It is worth noting that β includes all factors that affect the costs of intrafirm offshoring and arm's length offshoring equally. Particularly, for example, a drop in β can represents reductions in offshoring costs due to the establishment of special policy zones.

[16] The assumption of perfect transferability of production technology might be relaxed. It can be instead assumed that intrafirm offshoring has an offshoring cost of $\beta t\left(\frac{i}{K}\right) a_{Lj}$ while arm's length offshoring has an offshoring cost of $\beta t\left(\frac{i}{K}\right) A^{*} a_{Lj}$, where A^{*} is the technological inferiority of foreign firms. As long as A^{*} is assumed to be constant, the relaxation of the assumption does not change the results.

[17] Some business illustration of problems associated with offshoring communication can be found here: http://www.mpo-mag.com/articles/2006/10/your-top-10-outsourcing-problemssolved or http://www-

example, engineers are more easily co-located with workers under an intrafirm offshoring arrangement, so a more precise description or understanding of the problem is possible. People might also be more willing to communicate with those who are in the same organization with them. Or it could be that, under an intrafirm offshoring arrangement, it is easier for workers to find the right expert to diagnosis the problem.[18]

Since better communication leads to better description or understanding of the problem, the relative efficiency of communication in intrafirm offshoring is modeled as a larger number of words needed for intrafirm communication. I.e. $K_m = \delta\theta_j K_a$, where K_m and K_a are the number of words used by MNCs and arm's length suppliers respectively, and the constant, $\delta\theta_j > 1$, represents the superiority of communication in intrafirm offshoring.[19]

The superiority of intrafirm communication is decomposed into two parts. The organization-specific superiority, δ, captures the structure-inherent efficiency which is common across industries. For example, it captures the relative ease of arranging a face-to-face meeting between engineer and worker within the boundary of firm. The industry-specific superiority, θ_j, captures the communication intensity of the industry j. The larger the communication intensity, the larger the relative efficiency of communication in intrafirm offshoring than in arm's length offshoring. The intuition is that higher communication intensity requires better communication infrastructure, and intrafirm offshoring can better satisfy this need. For example, for industries that do not require frequent communication, exchange of emails may be efficient enough and it does not make a difference whether the communication is within the boundary of a firm or between arm's length parties. However, for industries that require frequent communication, face-to-face meetings may be necessary to solve encountered problems. Thus, intrafirm offshoring implies larger communication efficiency for industries with high communication intensity.[20]

935.ibm.com/services/us/gbs/bus/pdf/gbw03072-usen-00.pdf

[18] In practice, communication is more efficient if it is conducted between parties who both know the problems well, i.e. mechanical engineers talk to mechanical engineers, manufacturing personnel with their counterparts, etc. Under intrafirm offshoring this is relatively easier to realize because it is easier to organize communication among the entire team of workers. However, for arm's length offshoring, the assigned project manager at each organization who handles daily interactions is not necessarily an expert with respect to the encountered problem.

[19] It is implicitly assumed that tasks performed at home do not have any communication cost, i.e. $K_d \to \infty$ and $\beta_d = 1$, because nothing gets "lost in translation" and communication can be conducted face-to-face. When the firm's headquarters is not in the country where the tasks are performed, K is finite because problem-solving technology is not perfectly transferable to outside of the headquarters; and $\beta > 1$ because face-to-face communication is no longer available.

[20] One such industry is the computer industry. Since orders of computers are now highly "customized",

To make sure that it is impossible to offshore all tasks to a foreign country, the offshoring cost of the most complicated task, for example executive management, is assumed to be infinite even through intrafirm offshoring, i.e. $t(i/K_m) \to \infty$ if $i \to 1$.

In sum, there are three different factors that affect the offshoring costs. The first is the communication technology, β, capturing factors that affect both intrafirm offshoring and arm's length offshoring equally. The second is the complexity level of the task, determining the range of problems that workers may encounter. The last is the number of words, representing the relative efficiency of communication in different organizational forms. Without taking into account wages, the offshoring costs are then, $\beta t\left(\frac{i}{K_m}\right) a_{Lj}$ and $\beta t\left(\frac{i}{K_a}\right) a_{Lj}$ for intrafirm and arm's length offshoring, respectively.

2.2 Efficiency Wage

Foreign workers are hired by three different types of employers: MNCs, arm's length suppliers and other foreign indigenous firms.[21] Labor is free to move between arm's length suppliers and other foreign indigenous firms. The wages paid by these two types of firms are thus the same, denoted as w^*.

International monitoring is imperfect and workers working in MNCs have incentives to shirk due to disutility in making an effort. However, monitoring in arm's length suppliers is perfect due to the onsite monitoring by their owners, and hence workers in these firms will not shirk. In order to prevent workers from shirking, the MNCs must pay an efficiency wage premium compared with arm's length suppliers.

The efficiency wage, w_m, is determined by the oppotunity costs of shirking. Workers hired in MNCs have a natural exogenous quit rate, $b > 0$. Detection rate, $q > 0$, denotes the rate at which shirking is detected in MNCs. Workers who quit or are fired from MNCs are automatically hired by either arm's length suppliers or other foreign indigenous firms. Workers working in these firms tend to search for employment in MNCs because MNCs offer higher wages. The accession rate, e, denotes the rate at which new MNC jobs are aquired by

efficient communication of any changes to the order is thus critical to avoid waste and ensure timely delivery. This "made to order" production magnifies the organizational difference in communication efficiency (WTO 2008).

[21] Arm's length suppliers are different from other foreign indigenous firms in that arm's length suppliers perform tasks for home firms while other foreign indigenous firms produce finished goods for the foreign market.

non-MNC workers. Define V_{mn}, V_{ms} and V_a respectively as the expected lifetime utility of non-shirking MNC employees, shirking MNC employees, and the non-MNC workers. Assuming risk neutrality, the asset value equations applicable to the three groups of agents are

$$\rho V_{mn} = w_m - d + b\left(V_a - V_{mn}\right), \quad (1)$$

$$\rho V_{ms} = w_m + (b+q)\left(V_a - V_{ms}\right), \quad (2)$$

$$\rho V_a = w^* + e\left(V_{mn} - V_a\right), \quad (3)$$

where $\rho > 0$ is the discount rate and d is the disutility for not shirking. To prevent workers from shirking, MNCs must set w_m high enough so that $V_{mn} \geq V_{ms}$. However, they will only provide the lowest possible wage as long as workers do not shirk. I.e. MNCs set w_m such that $V_{mn} = V_{ms}$. This indicates

$$w_m = \rho V_a + \frac{\rho + b + q}{q} d. \quad (4)$$

Solving V_a from equation (1) and (3),

$$V_a = \frac{e\left(w_m - d\right) + (\rho + b)\, w^*}{\rho\left(\rho + e + b\right)},$$

and substituting in equation (4), the efficiency wage is determined by

$$w_m = w^* + \frac{\rho + b + q + e}{q} d.$$

In steady state, the number of workers flowing into MNCs must equal to the number of workers quiting or fired from MNCs. This implies that

$$e\left(L^* - L_m\right) = bL_m,$$

where L^* is the population in foreign country and L_m is the employment in MNCs. The "No Shirking Constraint" follows:

$$w_m\left(w^*, L^*, L_m\right) = w^* + \frac{\rho + q + b\left(\frac{L^*}{L^* - L_m}\right)}{q} d. \quad (5)$$

Equation (5) actually gives the labor supply function for MNCs. It is clear that the efficiency wage is an increasing function of the MNCs' employment, L_m. The intuition is that when employment in MNCs increases, the opportunity cost of shirking decreases due to the fact that the expected time spent in non-MNC firms is less. The incentive for shirking becomes stronger and MNCs must adjust the efficiency wage to a higher level. The relation between efficiency wage and MNC employment is shown by the supply curve in Figure 6. The position of the labor supply curve is determined by parameters such as the foreign wage and foreign population. For example, a decreasing foreign wage, w^*, or an increasing foreign population, L^*, makes shirking more costly and thus drives down the efficiency wage.

2.3 Organizational Forms

Based on the offshoring costs of different organizational forms, home firms decide whether to offshore each task, and if yes, whether in the form of intrafirm offshoring or the form of arm's length offshoring.

To produce good j, $j = \{X, Y\}$, the unit cost of performing task i at home is home wage times unit labor requirment, wa_{Lj}. Similarly, the cost of performing the same task in foreign country in the form of intrafirm offshoring is $\beta t\left(\frac{i}{K_m}\right)a_{Lj}w_m$, and $\beta t\left(\frac{i}{K_a}\right)a_{Lj}w^*$ in the form of arm's length offshoring. The marginal task performed at home has an index I_o such that the cost of performing it at home is the same as that if it is offshored, or

$$w = \min\left\{\beta t\left(\frac{I_o}{K_m}\right)w_m, \beta t\left(\frac{I_o}{K_a}\right)w^*\right\}.$$

The marginal task performed in the form of intrafirm offshoring has an index, I_m, such that the offshoring costs in different organizational forms are equalized, or

$$t\left(\frac{I_m}{K_m}\right)w_m = t\left(\frac{I_m}{K_a}\right)w^*. \tag{6}$$

There are only two possible outcomes, as shown in Figure 7: either all tasks are offshored in the form of arm's length offshoring, i.e. $I_m \geq I_o$, or simplest tasks are offshored in the form of arm's length offshoring and more complicated tasks are offshored in the form of intrafirm offshoring, i.e. $I_m < I_o < 1$.[22]

Only the latter case is of interest given the presence of intrafirm offshoring in reality. Then the cutoff offshored task, I_o, is determined by

$$w = \beta t\left(\frac{I_o}{K_m}\right)w_m. \tag{7}$$

[22] The simplest tasks would always be offshored in the form of armslength offshoring, if they are offshored. This is because $\beta t\left(\frac{0}{K_m}\right)w_m > \beta t\left(\frac{0}{K_a}\right)w^*$ always holds. This is in turn a result of $t(0) = 1$ and $w_m > w^*$. Then if there are both intrafirm offshoring and armslength offshoring, it must be that simplest tasks are offshored in the form of armslength offshoring and more complicated tasks are offshored in the form of intrafirm offshoring. This pattern of offshoring is supported by Costinot, Oldenski, and Rauch (2009).

Equations (6) and (7) together imply that

$$w = \beta t\left(\frac{I_o}{K_m}\right)\frac{t\left(\frac{I_m}{K_a}\right)}{t\left(\frac{I_m}{K_m}\right)}w^*. \tag{8}$$

I define $\varepsilon(z)$ as the elasticity of t function, i.e. $\varepsilon(z) \equiv \frac{t'(z)z}{t(z)}$, and assume that it is an increasing function.[23] Then equation (6) indicates that $\frac{\partial I_m}{\partial w_m} = \frac{1}{\zeta(I_m,\delta\theta_j)w^*} > 0$, where $\zeta(I_m,\delta\theta_j) = \frac{\partial\left(\frac{t\left(\frac{I_m}{K_a}\right)}{t\left(\frac{I_m}{K_m}\right)}\right)}{\partial I_m} = \frac{t\left(\frac{I_m}{K_a}\right)\bar{\varepsilon}}{t\left(\frac{I_m}{K_m}\right)I_m}$ and $\bar{\varepsilon} \equiv \varepsilon\left(\frac{I_m}{K_a}\right) - \varepsilon\left(\frac{I_m}{K_m}\right)$. This implies that given w^*, lower efficiency wage causes intrafirm offshoring more attractive and less tasks are performed in the form of arm's length offshoring. The range of tasks that are shifted from arm's length offshoring to intrafirm offshoring depends on $\zeta(I_m,\delta\theta_j)$, which measures the relatively faster growth of communication cost in arm's length offshoring compared with the communication costs in intrafirm offshoring. The larger the $\zeta(I_m,\delta\theta_j)$ is, the more difficult to shift tasks between different organizational forms. The main factor that affects this is the superiority of communication in intrafirm offshoring, $\delta\theta_j$, since $\frac{\partial\zeta(I_m,\delta\theta_j)}{\partial(\delta\theta_j)} > 0$.

2.4 Equilibrium

2.4.1 Home

In a competitive economy, the price of any good is less than or equal to the unit cost of production, with equality whenever a positive quantity of the good is produced. Assuming imperfect specialization, i.e. both countries produce both goods, then the prices are equal to the unit costs and profits are zero

$$p_j = wa_{Lj}(1-I_o) + w^*a_{Lj}\int_0^{I_m}\beta t\left(\frac{i}{K_a}\right)di + w_m a_{Lj}\int_{I_m}^{I_o}\beta t\left(\frac{i}{K_m}\right)di + sa_{Hj},\ j \in \{X,Y\},$$

where s denotes the high-skilled labor wage.

Substituting for w^* and w_m using equation (6) and (7) and taking good X as numeraire,

[23] This is not a very strong assumption. Examples includes exponential function $t(z) = e^z$, among others. Actually a sufficient condition for this assumption to hold is that for any integer n, the n^{th} derivative of t function is greater or equal to zero. Mathematically, for any such functions, the Taylor expansion at point zero is $t(z) = 1 + \sum_{n=1}^{\infty} a_n z^n$ where $a_n \geq 0$. It can be easily shown that the elasticity function, $\varepsilon(z) = \frac{\sum_{n=1}^{\infty} n a_n z^n}{1+\sum_{n=1}^{\infty} a_n z^n} = \frac{1}{\frac{1}{\sum_{n=1}^{\infty} n a_n z^n} + \frac{\sum_{n=1}^{\infty} a_n z^n}{\sum_{n=1}^{\infty} n a_n z^n}}$, is increasing in z. The second term in the denominator is decreasing in z since $\sum_{m=1}^{\infty} m a_m z^{m-1}\sum_{n=1}^{\infty} n a_n z^n < \sum_{m=1}^{\infty} a_m z^m \sum_{n=1}^{\infty} n^2 a_n z^{n-1}$ due to $2mn\left(a_m z^{m-1} a_n z^n\right) \leq \left(m^2+n^2\right)\left(a_m z^{m-1} a_n z^n\right)$.

the zero profit condition can be rewritten as

$$\begin{aligned} 1 &= \Omega\left(I_o, I_m\right) w a_{Lx} + s a_{Hx} \\ p &= \Omega\left(I_o, I_m\right) w a_{Ly} + s a_{Hy} \end{aligned}$$

where

$$\Omega\left(I_o, I_m\right) \equiv \left(1 - I_o\right) + \frac{1}{t\left(\frac{I_o}{K_m}\right)} \frac{t\left(\frac{I_m}{K_m}\right)}{t\left(\frac{I_m}{K_a}\right)} \int_0^{I_m} t\left(\frac{i}{K_a}\right) di + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right)}.$$

It is easy to show that Ω is a decreasing function of I_o and I_m, given that $\varepsilon\left(z\right)$ is increasing in z and $I_o > 0$. I.e.

$$\frac{\partial \Omega}{\partial I_o} = -\frac{\varepsilon\left(\frac{I_o}{K_m}\right)}{I_o t\left(\frac{I_o}{K_m}\right)} \left(\frac{t\left(\frac{I_m}{K_m}\right)}{t\left(\frac{I_m}{K_a}\right)} \int_0^{I_m} t\left(\frac{i}{K_a}\right) di + \int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di \right) < 0, \tag{9}$$

$$\frac{\partial \Omega}{\partial I_m} = -\frac{\int_0^{I_m} t\left(\frac{i}{K_a}\right) di}{t\left(\frac{I_o}{K_m}\right)} \frac{t\left(\frac{I_m}{K_m}\right)}{t\left(\frac{I_m}{K_a}\right) I_m} \bar{\varepsilon} < 0. \tag{10}$$

The intuition for $\frac{\partial \Omega}{\partial I_o} < 0$ is straightfoward. Offshoring more tasks, i.e. I_o increases, indicates that offshoring cost falls. The cost savings are much the same as would result from an economy-wide increase in the productivity of the low-skilled labor, i.e. a fall in Ω. The intuition of $\frac{\partial \Omega}{\partial I_m} < 0$ is similar. Increasing I_m indicates lower offshoring costs in arm's length offshoring. The cost savings are again the same as would result from an economy-wide productivity improvement for the lower-skilled labor, or a fall in Ω.

Finally, the home factor market clearing conditions are

$$\begin{aligned} a_{Lx}\left(\cdot\right) x + a_{Ly}\left(\cdot\right) y &= \frac{L}{1 - I_o}, \\ a_{Hx}\left(\cdot\right) x + a_{Hy}\left(\cdot\right) y &= H. \end{aligned}$$

2.4.2 Foreign Country

Let $A^* > 1$ denote the Hicks-neutral technological inferiority of foreign firms in both industries. The zero profit conditions and factor market clearing conditions are, respectively

$$\begin{aligned} 1 &= A^* w^* a_{Lx} + A^* s^* a_{Hx}, \\ p &= A^* w^* a_{Ly} + A^* s^* a_{Hy}, \end{aligned}$$

and

$$\begin{aligned} A^* a_{Lx} x^* + A^* a_{Ly} y^* + \beta \left(\int_0^{I_m} t\left(\frac{i}{K_a}\right) di + \int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di \right) (a_{Lx}x + a_{Ly}y) &= L^*, \\ A^* a_{Hx} x^* + A^* a_{Hy} y^* &= H^*. \end{aligned}$$

The total foreign labor demanded by intrafirm offshoring is

$$\begin{aligned} L_m &= (a_{Lx}x + a_{Ly}y)\,\beta \int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di \\ &= \frac{L\beta}{1 - I_o} \int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di, \end{aligned} \tag{11}$$

where the second equality comes from the home factor market clearing conditions. The intrafirm offshoring employment is determined by the task range performed by MNCs, $[I_m, I_o]$, and the communication technology (β). The impacts of I_o on L_m are both marginal and inframarginal. Increasing I_o causes more tasks to be offshored to MNCs. More importantly, it also causes an expansion of home production ($\frac{L}{1-I_o}$ increases). Such an expansion requires more units of each offshored task to be performed and thus increases MNC employment. The communication technology, β, affects the amount of labor demanded to perform each unit of task offshored.

Equation (6), (7) and (11) together provide labor demand function for intrafirm offshoring, given w and w^*. This is shown by the demand curve in Figure 6. It is downward sloping since lower w_m increases L_m. The intuition is that if the efficiency wage, w_m, falls and if w, w^* and β are fixed, then the range of tasks offshored in the form of intrafirm offshoring increases. Consequently the labor demanded by MNCs increases. The position of the labor demand curve is affected by w, w^* and β. Increasing w, increasing w^*, or increasing β all would increase the labor demanded by MNCs.

Finally, the model is closed with demand of goods. I assume that households have identical and homothetic preferences around the globe. Equilibrium in the goods market requires

$$\frac{y + y^*}{x + x^*} = D(p),$$

where $D(p)$ is the (homothetic) world relative demand for good Y and $D'(p) < 0$. If the home country is small in relation to the size of world markets, the relative price p can be treated as exogenous to the home economy. If the home country is large, the relative price is determined by an equation of world relative demand and world relative supply.

2.5 Effects of Falling Offshoring Costs

This model allows us to study the effects of a rich array of events. In this paper, I study the effects of a fall in offshoring costs on factor prices at home and on the relative prevalence of different offshoring organizational forms. In particular, I assume that there is an improvement in the communication technology such that β drops and all other exogenous variables remain fixed. Moreover, for simplicity, I assume that the home country is relatively small compared with the foreign country. This implies that the goods prices are not affected by improvements in the communication technology. Due to the well-known "factor price insensitivity" in Heckscher-Ohlin models, w^*, s^*, s and $w\Omega$ are then fixed, or

$$\hat{w} + \hat{\Omega} = 0, \tag{12}$$

where $\hat{w}$ and $\hat{\Omega}$ are the log changes of w and Ω respectively. Only the low-skilled labor wage at home is affected.[24]

Equation (5), (6), (7), (11) and (12) together provide the equilibrium solution, solving all endogenous variables w, w_m, L_m, I_m and I_o.

Substituting equation (6) and (11) into (5) gives

$$\frac{t\left(\frac{I_m}{K_a}\right)}{t\left(\frac{I_m}{K_m}\right)} = 1 + \frac{d}{w^*}\left(1 + \frac{\rho}{q} + \frac{b}{q}\left(\frac{L^*}{L^* - \frac{L\beta}{1-I_o}\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}\right)\right). \tag{13}$$

This suggests that I_m is an implicit function of I_o and β. The effects of changes in I_o and β on I_m are given by

$$\frac{\partial I_m}{\partial I_o} = \frac{t\left(\frac{I_o}{K_m}\right) + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{1-I_o}}{\zeta\left(I_m, \delta\theta_j\right)\frac{w^* q (L^* - L_m)^2 (1-I_o)}{LL^* b d \beta} + t\left(\frac{I_m}{K_m}\right)}, \tag{14}$$

$$\frac{\partial I_m}{\partial \beta} = \frac{\frac{1}{\beta}\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{\zeta\left(I_m, \delta\theta_j\right)\frac{w^* q (L^* - L_m)^2 (1-I_o)}{LL^* b d \beta} + t\left(\frac{I_m}{K_m}\right)}. \tag{15}$$

Both $\frac{\partial I_m}{\partial I_o}$ and $\frac{\partial I_m}{\partial \beta}$ are positive given that $\varepsilon(\cdot)$ is an increasing function.

These two equations are important. They show the channels through which organizational form choice affects the gains from trade. As shown in equation (10), increasing I_m leads to lower Ω, and equation (12) shows the negative relation between Ω and the home wage.

[24] Because the home low-skilled labor wage is the only one that changes, in order to avoid confusion the "home wage" hereafter refers to "home low-skilled labor wage", unless otherwise noted.

Thus, the impact of falling offshoring costs on the range of tasks performed via arm's length offshoring will consequently affect the home wage.

The intuition of $\frac{\partial I_m}{\partial I_o} > 0$ is as follows. When I_o increases, employment in MNCs increases due to both inframarginal and marginal expansion of intrafirm offshoring. Increasing labor demand in MNCs makes shirking less costly since it becomes easier to get re-hired in MNCs. To offset stronger incentives for shirking, MNCs must increase the efficiency wage, w_m. However, higher efficiency wages paid by MNCs make arm's length offshoring relatively cheaper. Firms will then shift some tasks from intrafirm offshoring to arm's length offshoring, i.e. I_m increases. The effect that expansions in MNC labor demand lead to more tasks offshored in the form of arm's length offshoring is referred as the "MNC expansion effect".

The intuition of $\frac{\partial I_m}{\partial \beta} > 0$ is similar. When there is a fall in β, the labor demanded to perform each unit of task is lower due to more efficient communication. This causes lower employment in MNCs which in turn makes shirking more costly. MNCs can accordingly offer a lower efficiency wage and save in offshoring costs. Moreover, this extra saving in MNCs makes intrafirm offshoring relatively cheaper and thus induces shifts of tasks from arm's length offshoring to intrafirm offshoring. I.e. I_m would decrease accordingly. The effect that falling offshoring costs lead to lower efficiency wages in MNCs due to lower employment in MNCs is referred as the "indirect cost saving effect".

These two effects affect I_m in opposite directions. Later I will show that in equilibrium a fall in offshoring cost, β, leads to larger range of tasks offshored. The MNC expansion effect then drives up I_m and the indirect cost saving effect drives it down. The overall effect on I_m depends on the relative magnitudes of these two effects. If a fall in β leads to a large change of I_o, then the MNC expansion effect would dominate and I_m would increase. Otherwise the indirect cost saving effect dominates and I_m decreases. The relative magnitudes of these two effects in turn depend on the functional form of the offshoring cost function and the communication intensity of the industry. I will discuss this in detail later.

Equations (8), (12) and (13) then solve the three unknowns, w, I_o and I_m (for details, see appendix A):

$$\hat{w} = \frac{-\frac{\partial\Omega}{\partial I_o} + \frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial\beta}\beta\frac{\varepsilon\left(\frac{I_o}{K_m}\right)}{I_o t\left(\frac{I_o}{K_m}\right)}\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di - \frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o}}{\frac{1-I_o}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right) + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right)\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial I_o}}\left(-\hat{\beta}\right) \tag{16}$$

$$dI_o = \frac{\Omega + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right)\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial\beta}\beta}{\frac{1-I_o}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right) + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right)\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_o}{\partial I_o}}\left(-\hat{\beta}\right) \tag{17}$$

$$dI_m = \left(\frac{\Omega\frac{\partial I_m}{\partial I_o} - \frac{1-I_o}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)\frac{\partial I_m}{\partial\beta}\beta}{\frac{1-I_o}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right) + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right)\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial I_o}}\right)\left(-\hat{\beta}\right) \tag{18}$$

It is obvious that a fall in offshoring cost, β, always induces a larger range of tasks to be offshored and a higher home wage, i.e. $\hat{w} > 0$ and $dI_o > 0$ if $\hat{\beta} < 0$.

2.5.1 Decomposing Effects on Home Wage

The effect of a fall in offshoring costs on home low-skilled labor wage in the small open economy case is called the "productivity effect" in Grossman and Rossi-Hansberg (2008). This is because falling offshoring costs cause lower Ω, which is similar in nature to an economy-wide increase in the productivity of the low-skilled labor. With the presence of different organizational forms, falling offshoring costs could affect the home wage through more channels besides the one identified in Grossman and Rossi-Hansberg (2008). Equation (16) shows that the productivity effect can be decomposed into three subeffects.

The first subeffect is the one identified in Grossman and Rossi-Hansberg (2008), shown by the term which includes $\frac{\partial\Omega}{\partial I_o}$ in equation (16). It contributes positively to the productivity effect. The intuition is that a fall in β causes both inframarginal and marginal cost savings of offshoring, regardless organizational form. These cost savings induce a higher home wage as a productivity improvement of home labor does so. Mathematically, because offshoring becomes more attractive relative to performing tasks at home, more tasks are offshored, i.e. I_o increases. Since $\frac{\partial\Omega}{\partial I_o} < 0$, increasing in I_o causes a fall in Ω, which in turn increases home wage according to equation (12). I call this the "direct cost saving effect" in the sense that falling β directly causes savings in offshoring costs.

The second subeffect is an extra cost saving for intrafirm offshoring due to lower efficiency wages induced by communication technology improvement, identified above as the "indirect cost saving effect". The intuition is that falling offshoring costs reduce employment in MNCs because labor demanded to perform each unit of task becomes lower. This discourages shirking and allows MNCs to pay a lower efficiency wage. Mathematically, this effect is shown by the term which includes $\frac{\partial I_m}{\partial \beta}$ in equation (16). Since $\frac{\partial I_m}{\partial \beta} > 0$, this effect contribute positively to home low skilled wage.

Finally, the last subeffect causes an increase in offshoring cost for intrafirm offshoring, identified as the "MNC expansion effect". Intuitively, larger I_o and smaller I_m implied by the first two subeffects indicate that the range of tasks performed in MNCs are larger. Moreover, home production expansion demands more units of tasks to be performed in MNCs. This increases the labor demanded by intrafirm offshoring, encouraging shirking and forcing MNCs to offer higher efficiency wages. The higher efficiency wage partially offsets the previous two cost savings effects, inducing a lower home wage. Mathematically, this effect is shown by the terms that include $\frac{\partial I_m}{\partial I_o}$ in equation (16). Since this effect induces higher I_m and $\frac{\partial \Omega}{\partial I_m} < 0$, it consequently leads to higher Ω and lower wage at home.

Notice that the indirect cost saving effect and the MNC expansion effect both work through the labor market for intrafirm offshoring, my model thus identifies the important impacts of the organizational form choice on the productivity effect. The labor market for intrafirm offshoring plays an important role in determining whether the productivity effect is larger or smaller. Since labor demand for intrafirm offshoring is positively related to the efficiency wage, if the labor demanded by intrafirm offshoring becomes larger, then efficiency wages paid by MNCs are higher and the productivity effect is lower. On the other hand, if the labor demand is lower due to reductions in offshoring costs, then efficiency wages are lower. Then there could be extra cost savings for intrafirm offshoring and the productivity effect becomes larger.

Although the MNC expansion effect partially offsets the direct and indirect cost saving effects, the overall effect of a fall in offshoring costs on home wage is positive, suggested by the positive $\hat{w}$ in equation (16). The proposition follows,

Proposition 1 *The productivity effect can be decomposed into three subeffects: the direct* *cost saving effect, the indirect cost saving effect and the MNC expansion effect. The direct cost saving effect comes from decreasing offshoring costs in both organizational forms directly due to lower offshoring costs. The indirect cost saving effect comes from lower efficiency wages in MNCs due to lower demand of labor in MNCs to perform each unit of tasks. The MNC expansion effect stems from higher efficiency wages in MNCs due to expansion of home production and the range of tasks performed in the form of intrafirm offshoring. Both the direct and indirect cost saving effects cause higher home wage. However, they are partially offset by the MNC expansion effect. The overall productivity gain from a fall in offshoring cost is always positive.*

2.5.2 Decomposing Effects on Orgnizational Forms

Equation (17) shows that a larger range of tasks would be offshored if the offshoring cost falls. However, the relative prevalence of different offshoring organizational forms is much less clear. Equation (14) and (15) show that the range of tasks performed in the form of arm's length offshoring (I_m) is determined by the range of tasks offshored (I_o) and the communication technology (β). Moreover, according to equation (7), the range of tasks offshored is also related to equilibrium home wage (w). Thus the impact of a fall in offshoring cost on the relative prevalence of different organizational forms, which is defined as the range of tasks offshored in intrafirm offshoring relative to that in arm's length offshoring, $(I_o - I_m)/I_m$, also works through three channels, β, I_o and w.

The labor market for intrafirm offshoring helps us to understand these three channels. This is because the prevalence of different organizational forms is partly determined by the range of tasks offshored in arm's length offshoring, I_m, which in turn is monotonically related to the efficiency wage, w_m, shown by equation (6). The efficiency wage itself is in turn determined by the labor market for intrafirm offshoring, especially the labor demand since the position of labor supply curve is fixed. Figure 8 depicts these three channels explicitly.

First, falling β indicates that for each unit of task less foreign labor is demanded. This drives down the labor demand for intrafirm offshoring. Graphically, this effect shifts the demand curve down from position D_o to D_1 in Figure 8. Thus the efficiency wage is lower and intrafirm offshoring becomes more prevalent. This is exactly the impact of the indirect cost saving effect on organizational form choice. It is shown in Figure 9.

Second, keep the home wage, w, fixed, falling β indicates cheaper offshoring and more tasks to be offshored. I.e. I_o would increase as suggested by equation (7). As noted above, larger I_o means both inframarginal and marginal expansion of intrafirm offshoring and drives up the labor demand for intrafirm offshoring. This shifts the labor demand curve up from position D_1 to D_2 as shown in Figure 8. The larger labor demand for intrafirm offshoring drives up the efficiency wage and causes intrafirm offshoring less prevalent. This channel works through the MNC expansion effect and is shown by Figure 10.

Finally, the productivity effect increases the home wage, which in turn makes offshoring relatively cheaper. I_o increases further as indicated by equation (7), and labor demand for intrafirm offshoring increases further. It shifts the demand curve up further from position D_2 to D_3 in Figure 8 and leads to further increase in efficiency wage, causing intrafirm offshoring less prevalent. The impact of increasing home wage on the relative prevalence of intrafirm offshoring is shown by Figure 11.

Among these three subeffects, which one dominates depends on the final position of the labor demand curve since the labor supply curve is fixed. If a fall in offshoring cost causes either large change of home wage, w, or large change of the range of task offshored, I_o, then the last two subeffects dominate and efficiency wage would increase, so does I_m. Otherwise the first subeffect dominates.

The proposition follows,

Proposition 2 *The effect of falling offshoring costs on the range of tasks performed in arm's length offshoring (I_m) can be decomposed into three subeffects. First, falling offshoring costs directly decrease the labor demanded to perform each unit of tasks in MNCs. This causes lower efficiency wage and smaller range of tasks offshored in the form of arm's length offshoring. Secondly, falling offshoring costs cause expansions of home production and a larger range of tasks offshored, which in turn increase the MNC labor demand. The efficiency wage increases and more tasks are offshored in the form of arm's length offshoring. Finally, falling offshoring costs drives up home wage, causing more tasks offshored and larger MNC labor demand. This again increases the efficiency wage and consequently increases the range of tasks offshored in the form of arm's length offshoring. The overall effect is ambiguous and depends on the relative maganitude of each subeffect.*

I now study under what situations intrafirm offshoring becomes more prevalent when offshoring cost falls. Since $dI_o > 0$ always holds when offshoring cost drops, the sign and the magnitude of dI_m in equation (18) then determine the relative prevalence of intrafirm offshoring. I identify two situations under which intrafirm offshoring becomes relatively more prevalent. The first situation is when I_o increases while I_m decreases and the second situation is when I_m increases, but increases less than I_o.

The first situation happens if the $t\left(\frac{i}{K_m}\right)$ function increases "fast" enough in i at point I_o. The intuition is that if the offshoring cost function is steep, a big fall of offshoring cost can only cause few new tasks to be offshored in the form of intrafirm offshoring. The big fall of offshoring cost leads a large drop of labor demand for intrafirm offshoring. On the other hand, the small range of newly offshored tasks leads to a small increase in labor demand for intrafirm offshoring. The net effect is thus a fall in labor demand for intrafirm offshoring and a lower efficiency wage. It consequently makes intrafirm offshoring more attractive relative to arm's length offshoring and intrafirm offshoring becomes more prevalent.

Proposition 3 *The range of tasks offshored in the form of arm's length offshoring would decrease with falling offshoring costs if and only if the offshoring cost function $t\left(\frac{i}{K_m}\right)$ increases sufficiently fast with i at I_o such that $\varepsilon\left(\frac{I_o}{K_m}\right) > \frac{I_o}{(1-I_o)}\frac{\Omega}{(1-I_o)}\left(\frac{t\left(\frac{I_o}{K_m}\right)(1-I_o)}{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di} + 1\right)$.*

Proof. See appendix B. ■

The second situation happens when falling offshoring costs cause the ratio of $\frac{I_o - I_m}{I_m}$ increases even when I_m increases, i.e. $d\left(\frac{I_o - I_m}{I_m}\right)/d\beta < 0$. This would be the case if the industry is sufficiently communication intensive, i.e. θ_j is large enough. The intuition is that if θ_j is sufficiently large, for a small increase in I_m, the offshoring cost of arm's length offshoring would increase much faster than that of intrafirm offshoring, i.e. $\zeta\left(I_m, \delta\theta_j\right)$ is large enough. Thus it is more difficult for firms to transfer tasks from intrafirm offshoring to arm's length offshoring. Thus although falling offshoring cost causes firms offshore more tasks abroad, far fewer tasks are shifted from intrafirm offshoring to arm's length offshoring.

Proposition 4 *If the industry is sufficiently communication intensive, i.e. if θ_j is sufficiently large, intrafirm offshoring becomes relatively more prevalent with falling offshoring costs, i.e. $\frac{I_o - I_m}{I_m}$ increases when β falls.*

Proof. See appendix C. ■

Proposition 4 implies that reductions in offshoring costs tend to lead to larger intrafirm offshoring share for industries that are more communication intensive. More specifically, if the range of tasks offshored in the form of arm's length offshoring increases, reductions in offshoring costs would cause a larger increase in intrafirm offshoring share for industries that are more communication intensive.[25] The intuition is straightforward. The more communication intensive the industry is, the more difficult to transfer tasks from intrafirm offshoring to arm's length offshoring. Thus, intrafirm offshoring would increase faster than arm's length offshoring in industries of high communication intensity.

3 Data and Econometric Evidence

The theoretical model predicts that reductions in offshoring costs lead to a larger increase in the intrafirm offshoring share for industries that are more communication intensive. In this section, I test this hypothesis by examining how reductions in offshoring costs that are due to the establishment of export processing zones affect the organization of Chinese offshoring over the period of 1997 to 2007. I find strong evidence in support of the model's prediction: while offshoring cost reductions have an insignificant effect on the intrafirm offshoring share in the least communication-intensive industries, similar reductions in offshoring costs are associated with a eight percentage point increase in the intrafirm offshoring share for the most communication-intensive industries.

In the following subsections, I first provide a brief introduction of special policy zones in China and why they cause lower offshoring costs. I then describe the dataset used in the paper, followed by the empirical specfications and estimation results. Finally, I close the section with various robustness checks.

3.1 Special Policy Zones and Offshoring Cost

Chinese cities offer a number of different special policy zones. They were set up in different periods and for different purposes. The major special policy zones are Special Economic Zones (SEZs), Economic and Technology Development Areas (ETDAs), Hi-Tech Industry

[25] Notice that when $dI_m > 0$, when $\theta_j \to \infty$, $\frac{dI_m}{dI_o} \to 0$, indicating that intrafirm offshoring becomes relatively more prevalent for industries that are more communication intensive.

Development Areas (HTIDAs) and Export Processing Zones (EPZs).[26] SEZs were setup in the early years when China adopted "Open-Door Policy". The first four SEZs were established in 1980 and another was established in 1988. SEZs typically cover a city but Hainan SEZ covers the whole province. ETDAs were established later, 14 in 1984, 18 in 1993 and another 18 after 2000. They enjoy preferential policies that were granted earlier only to SEZs but have relatively smaller size than SEZs. ETDAs policies focus on attracting investments and development of the local economy. HTIDAs were set up at roughly the same period of ETDAs but emphasize high-technology industries. The special policy zones that are most relevant to my study are EPZs. They were all set up after 2001 and only focus on facilitating export processing. In principle EPZs are sub-areas in established ETDAs, although there are some exceptions. By 2009 there were 5 SEZs, 54 ETDAs, 56 HTIDAs and 58 EPZs in total. Special policy zones are very widely distributed, although provinces on the east coast have a larger portion. Each province typically has at least one special zone of each type.[27]

Besides these special policy zones, there are other types of zones. Bonded Areas, National Border & Economic Cooperation Zones, and Taiwan Investment Zones are notable ones. Moreover, there are 1,346 *provincial* level special zones (mainly ETDAs and HTIDAs) by 2006. Central government's favorable policies toward special zones do not apply in provincial level zones but local governments may provide their own favorable policies. I ignore these special policy zones either because they are less relevant to processing trade or because provincial zones are not identified by the Chinese custom.[28]

Special zones play important roles in the growth of export processing by Wholly-Foreign-Owned firms (WFOs). Table 1 decomposes the year-by-year growth of export processing by WFOs into different types of zones.[29] It is clear that special zones contribute about half of the growth each year, within which the EPZs' share was continuously increasing, from 7.7%

[26] The term "EPZ" here is a narrower term than that is used by International Labor Office (ILO). The ILO use "EPZ" to refer to all types of special policy zones in China, including SEZs, ETDAs, HTIDAs and EPZs (ILO 1998). Some studies follow ILO in studying special policy zones in China (Reinert and Rajan 2008). However, this is not accurate because special zones such as SEZs, ETDAs and HTIDAs are not exclusively designed for export processing.

[27] A brief description of special policy zones is provided by http://www.usembassy-china.org.cn/fcs/china%20pulse/regional_dftz_may.doc. Wong and Tang (2005) provide a case study.

[28] One thing that worth to note is that excluding these special zones does not weaken my empirical conclusion since they tend to cause downward bias of the estimates.

[29] In the table, Bonded Areas (BAs) are also reported. However, given that only very limited activities, such as freight classification, loading of parts, storing, packing, and branding, are allowed in BAs, they are not included in the empirical analysis.

in 2002 to 58.5% in 2008.

Special zones provide lower offshoring cost in three ways. First, special zones provide preferential tax and special management policies that reduce offshoring costs. Income taxes are usually fully exempted or reduced to half in all types of special zones. EPZs feature some extra special management of export processing, which other types of special zones do not provide. These special treatments, for example, include exemptions on import and export quota and licensing administration, exemptions on *Bank Deposit Account* management and *Registration Manual* management, exemptions on value-added tax and exemptions on duties of all imports and exports. Moreover, firms in EPZs also benefit from priority Customs clearance, more streamlined clearance and 24-hour Customs support.

Second, modern developed infrastructure, rich human resources and efficient management and services provided by the special zones help to decrease offshoring costs. Special zones typically have better infrastructure in transportation, informational technology, and supply of electricity, water, gas and steam. Most zones feature a one-stop severice center to help firms to avoid complicated and prolonged approvements and other bureaucratic issues. Some special zones may even have "tailored policies", providing tailored service and flexible policies to large firms. A survey conducted in Weihai ETDA in 2006 suggests that government efficiency, transportation convenience and policy consistency are the most important factors that attracts investments to the zone.[30]

Finally, special zones may trigger the formation of industrial clusters which in turn provide lower offshoring costs. Anecdotal evidence suggests that moving in of one firm to a special policy zone could cause related firms to be located closer.[31] Timely input supply and zero inventory requirement made available by industrial clusters consequently make production more efficient. For instance, Kunshan ETDA in Jiangsu province has about 24 firms producing computers and network equipments while 300 local upstream suppliers are located around.[32]

3.2 Data

The main dataset is the Chinese International Trade Dataset obtained from China Customs General Administration. It includes information on product of processing export (HS 8-digit),

[30] http://www.cadz.org.cn/news/content_news.jsp?ContentID=15554
[31] http://www.cadz.org.cn/news/content_news.jsp?ContentID=18293
[32] http://www.cadz.org.cn/news/content_news.jsp?ContentID=51475

origin city or zone and firm ownership, over the period 1997-2007.

The measure of intrafirm offshoring share is constructed by WFOs' share of processing export ($Intrashare$). Processing trades by other types of Foreign-Invested-Firms (FIEs), such as Equity-Joint-Ventures (EJVs) and Contractual-Joint-Ventures (CJVs), are regarded as arm's length offshoring. This is because domestic partners might have considerable influence on the production in these arrangements. Of course, processing trade by domestic firms is regarded as arm's length offshoring as well.

Although direct measures of offshoring costs are not readily available, I construct two types of proxies that are presumably correlated with offshoring costs. The first type proxies are dummy variables indicating whether there are certain special policy zones in a city. Two such dummies, HT and EPZ, are constructed. The dummy variable HT equals to one if the city has any of SEZ, ETDA or HTIDA, and equals to zero otherwise. The reason that these three special zones are grouped together is that the preferential policies in these zones are very similar. Moreover, the line between ETDAs and HTIDAs is often blurred in practice and there is a trend for cities to join these zones together. Similarly, the dummy variable EPZ equals to one if cities have EPZs and equal to zero otherwise.[33] As discussed above, special policies and management in EPZs are designed particularly to facilitate processing trade. Thus variable EPZ is the main focus of the empirical analysis.

The second type proxy of offshoring cost is a proxy for transportation infrastructure: the ratio of passengers, taking railway or highway transportations, to the total population ($Trans$). It is constructed using a separate city level dataset, China City Statistics, obtained from the China Data Center at University of Michigan (1997-2007).

Moreover, two other city level variables are included in the empirical model: non-agriculture population (NAP) and the number of students in secondary schools (NSS). These variables identify labor supply effects on the relative prevalence of different organizational forms. According to the theory, increasing labor supply should lower the efficiency wage and consequently increase the share of intrafirm offshoring, provided that non-MNCs absorb all remaining workers.[34] Thus the estimates of these variables provide a side support of the theory

[33] One thing should be noticed is that 19 ETDAs, 3 HTIDAs and 7 EPZs are not observed in the dataset because the codes for these special zones are not provided by the Chinese Custom. However, again, this would strengthen the empirical conclusion since it causes downward bias of the estimates.

[34] The theoretical proof is not provided to save space but available upon request.

if they have expected signs.

The measure of industry's communication intensity (*cintense*) is constructed using the O*NET dataset and the OES (Occupational Employment Statistics for USA) dataset for year 2000.[35] Following Costinot, Oldenski, and Rauch (2009), each 2-digit occupation is first assigned an index based on the occupation's requirement of capability of "making decisions and solving problems". Then the measure of communication intensity of each industry is constructed using the weighted average of this index across all 2-digit occupations, where the weights are occupations' employment shares in this industry.[36] Table 2 list industries that are most or least communication intensive.

Table 3 provides some basic statistical information of main variables.

3.3 Empirical Specifications

The basic empirical model is

$$\begin{aligned} Intrashare_{jct} = {} & \alpha_{jc} + \alpha_t + \beta_1 EPZ_{ct} + \beta_2 EPZ_{ct} \cdot cintense_j \\ & + \beta_3 HT_{ct} + \beta_4 NAP_{ct} + \beta_5 NSS_{ct} + \beta_6 Trans_{ct} + \varepsilon_{jct}. \end{aligned} \tag{19}$$

As discussed above, the dependent variable, $Intrashare_{jct}$, is the intrafirm offshoring share of product j in city c in year t. EPZ_{ct} equals to unit if city c has an EPZ in year t, and equal to zero otherwise. $EPZ \cdot cintense$ is the interaction term of EPZ dummy and communication intensity. HT_{ct} equals to unit if city c has any SEZ, HTIDA or ETDA in year t, and equal to zero otherwise. NAP_{ct} and NSS_{ct} are respectively the number of non-agriculture population (in million persons) and the number of students in secondary schools (in million persons) in city c in year t. $Trans_{ct}$ is the proxy of transportation infrastructure, the ratio of passengers taking railway or highway transportation to the total population in city c in year t. Finally, α_{jc} is the product-city fixed effect and α_t is the year fixed effect.[37] The idiosyncratic effect is assumed to have a normal distribution, $\varepsilon_{jct} \sim N\left(0, \sigma_c^2\right)$.

The main focus is the coefficient of the interaction term $EPZ \cdot cintense$. The theory predicts that reductions in offshoring costs lead to a larger increase in intrafirm offshoring

[35] It is implicitly assumed that the same industry has the same communication intensity in China and US .
[36] This measure is then rescaled so that the index is in the range of $[0, 1]$ when it is used empirically.
[37] Notice that the product-city fixed effect is more powerful than product fixed effect and city fixed effect together.

share for industries that are more communication intensive. Thus it is expected that this coefficient has a positive sign. Moreover, since a decrease in offshoring costs or a increase in labor supply in foreign country are predicted to lead to a larger share of intrafirm offshoring, the expected signs of coefficients of variables, HT, NAP, NSS and $Trans$ are positive.

The consistent estimation of the basic specification depends on a strong assumption that the regressors are strictly exogenous, i.e they are not correlated with ε_{jct} in any period. However, it is possible that designation of special zones is correlated with product-city specific trends. Cities with faster growing intrafirm offshoring might have larger incentives to apply for certain special zones. To control the product-city specific trends, a "random trend" is added to the basic model[38]

$$\begin{aligned} Intrashare_{jct} = {} & \alpha_{jc} + \alpha_t + g_{jc}t + \beta_1 EPZ_{ct} + \beta_2 EPZ_{ct} \cdot cintense_j \\ & + \beta_3 HT_{ct} + \beta_4 NAP_{ct} + \beta_5 NSS_{ct} + \beta_6 Trans_{ct} + \varepsilon_{jct} \end{aligned}$$

where g_{jc} captures product-city specific trend. To estimate this model, it is first differeced,

$$\begin{aligned} \Delta Intrashare_{jct} &= \lambda_t + g_{jc} + \beta_1 \Delta EPZ_{ct} + +\beta_2 \Delta EPZ_{ct} \cdot cintense_j \\ & \quad + \beta_3 \Delta HT_{ct} + \beta_4 \Delta NAP_{ct} + \beta_5 \Delta NSS_{ct} + \beta_6 \Delta Trans_{ct} + \Delta\varepsilon_{jct} \quad (20) \end{aligned}$$

where $\lambda_t = \alpha_t - \alpha_{t-1}$ is a new set of year fixed effects. Estimating the first differenced equation (20), both product-city fixed effect, α_{jc}, and product-city specific trend, g_{jc}, are allowed to be correlated with independent variables.

In sum, two types of models are estimated, the basic model (equation (19)) and the random trend model (equation (20)).

3.4 Main Estimation Results

This section reports the estimation results of the above models in table 4. For the basic model, within (FE) estimates and first differencing (FD) estimates are reported in column 1 and column 2 respectively. The reported standard errors are clustered at city level to avoid the intraclass correlation and serial correlation (Bertrand, Duflo, and Mullainathan (2004) and Angrist and Pischke (2009)). The coefficient of the EPZ dummy is negative for both within estimates and first difference estimates, though insignificant for the first difference estimates.

[38] See Wooldridge (2002) section 11.2 and Papke (1994).

The coefficient of the interaction term of EPZ dummy and communication intensity is positive and significant at 10% and 5% level respectively for within estimates and first difference estimates. All other coefficients are of the expected sign, among which the nonagriculture population of the city and the transportation infrastructure proxy seem to have positive and highly significant impacts on the intrafirm offshoring share.

Column 3 to 4 report the within estimates and first difference estimates respectively for the random trend model. Again, the coefficient of the EPZ dummy is negative but statistically insignificant. The coefficient of the interaction term of EPZ dummy and communication intensity is positive and significant at 5% level. Since the communication intensity measure is rescaled to $[0, 1]$, these results indicate that for the least communication intensive industries, there is no significant change to the intrafirm offshoring share when the city establish an EPZ. However, the establishment of the EPZ can lead to an 8 percentage point $(9.009 - 1.05)$ increase in the intrafirm offshoring share for the most communication intensive industries.

Nonagriculture population and the transportation infrastructure proxy again have positive and highly significant impacts on the intrafirm offshoring share. A one million increase in nonagriculture population increases the share of intrafirm offshoring by 3.76 percentage points on average for all industries. Similarly, a one unit change of transportation infrastructure proxy is associated with 0.08 percentage point increase in intrafirm offshoring share on average for all industries. The dummy for other special policy zones is not statistically signifiant or only significant at 10% level. The student number in secondary schools also has no significant impact on the intrafirm offshoring share, probably because it does not correlate with the current labor supply.

I take the random trend model estimates as my benchmark results. Using these results, in table 5 I calculate the predicted percentage increases of intrafirm offshoring share for years 1997-2007 based on the average communication intensity and the average intrafirm offshoring share. The results show that on average, establishment of an EPZ lead to a 3.3% to 5.7% increase in intrafirm offshoring share. Given that the intrafirm offshoring share increases only around 2 to 5 percentage points each year and that there may be other forms of reductions in offshoring costs besides establishments of EPZs, reductions in offshoring costs can explain a large portion of the intrafirm offshoring share increase.

In sum, across different specifications, establishments of EPZs in cities are estimated to have statistically insignificant effects on intrafirm offshoring share for industries with lowest level of communication intensity. However, for industries that are most communication intensive, they have positive and signifant impacts on the intrafirm offshoring share. Since EPZs provide considerable cost savings for export processing, it is safe to conclude that reductions in offshoring costs induce a larger increase in the intrafirm offshoring share for industries that are more communication intensive.

3.5 Robustness Checks

One might worry that some other reasons, other than falling offshoring costs, might explain why setting up special policy zones leads to larger share of intrafirm offshoring. For example, it could be that preferential policies applied in the special zones discriminate against domestic firms, thereby inducing faster growth in intrafirm offshoring. One may also worry that given the difference-in-difference nature of the empirical model, it is not appropriate to use cities in one province as control groups for cities in another province. This section addresses these issues.

It seems plausible that preferential policies may induce a larger intrafirm offshoring share. However, preferential policies per se cannot explain why the establishment of EPZs have different impacts on the intrafirm offshoring share for different industries. In this sense, the empirical finding that reductions in offshoring costs following the establishment of EPZs leads to a larger increase in the intrafirm offshoring share for industries that are more communication intensive is robust to this alternative explanation.

More formally, there are two ways to rule out the preferential policy explanation. First, we may check the responses of different types of foreign firms to EPZs. As discussed above, there are three types of foreign invested firms: WFOs, EJVs and CJVs. The preferential policies towards foreign firms apply equally to all types of FIEs. If different responses to special policy zones by different types of foreign firms are observed, then preferential policies towards FIEs can be ruled out as the sole explanation of the increasing share of intrafirm offshoring.

In order to test whether there are differences in responses to special zones by different types of foreign firms, the dependent variables in the benchmark specifications are replaced by the WFOs' share of export processing by all types of FIEs ($IntrashareFIE_{jct}$). Both the basic model and random trend model are re-estimated and the results are shown in table 6. The results are very similar to those in the benchmark estimations. The only difference is that the coefficient on the HT dummy is highly significant in most specifications. These results indicate that different types of foreign invested firms respond differently to the establishments of EPZs and that discriminatory policies against domestic firms cannot solely explain the faster growth of WFOs' processing exports.

The second way to rule out preferential policy as the sole explanation is to make use of firms' responses to EPZs in cities where other types of special zones have already been established. The rationale is that discrimination policies are similar in all types of special zones and EPZs differ from other special zones mainly in providing extra policies that faciliate export processing. More importantly, these extra policies in EPZs do not discriminate by firm type. Thus, if in cities where other types of special zones have already been established the intrafirm offshoring share increases when the city establishes EPZs, then it must be due to the extra policies provided by EPZs and not by the discriminatory policies against domestic firms. Differential setup timing for special zones allows us to test this. EPZs are typically set up later than ETDAs. More importantly, they are generally established within the confines of existing special zones, usually ETDAs.

The sample is thus restricted to a subsample that contains observations where cities already have some SEZs, ETDAs or HTIDAs. Both models are estimated again. Since the HT dummy is now time invariant it is excluded from the models. The results are shown in table 7 and are similar to previous results. The difference is that the coefficient on the interaction term between EPZ dummy and communication intensity is relatively smaller and is significant at the 10% level for the first difference estimate of the random trend model. The other notable difference is that the $Trans$ variable is not significant now in most models.

Finally, because the empirical model is essentially a difference-in-difference estimation, one may worry that pooling all observations of all provinces introduces the risk of comparing non-comparable cities. For example, using cities in Tibet as a control group for a city in Guangdong province may not be valid, since these two provinces are so different. More formally, this problem would be important if there exists a province-year fixed effect, α_{pt}, where p stands for province, and if this fixed effect is correlated with the regressors.

This province-year fixed effect can potentially be included in and identified by the previous models, if a full set of province-year dummies are included. However, this would introduce 341 new dummies (31 provinces and 11 years) which may lead to too many degrees of freedom. Without including the full set dummies, in previous estimates, the random trend model partially controls for this fixed effect by including the product-city specific trend. Moreover, since about 92% of all observations in the sample are coming from the East region of China, where cities can be thought of as relatively homogeneous, this problem should not have big influences on the estimates.

To further evaluate this problem, a subsample that only includes provinces in the East region is used to re-estimate both the models.[39] The results, as shown in table 8, are very similar to previous results. The only noticable difference is that the HT dummy is highly signifiant in most specifications. This indicates that the province-year fixed effect does not matter too much and the benchmark results are reliable.

4 Conclusion

I have developed a general equilibrium framework to study task trading and organizational forms. In my model, firms are motivated to offshore heterogeneous tasks and choose an organizational form based on cost considerations. The prohibitively high communication costs associated with the most complicated tasks lead these tasks to be performed at home. When making organizational form decisions with respect to offshored tasks, firms trade off the benefits of lower communication costs via intrafirm offshoring against paying higher wages. This tradeoff induces firms to offshore the least complex tasks in the form of arm's length offshoring and other tasks in the form of intrafirm offshoring.

The model is used to study the effects of reductions in offshoring costs on factor prices and on the relative prevalence of different organizational forms. One key prediction of the model is that reductions in offshoring costs will cause a larger increase in intrafirm offshoring share for the industries that are the most communication-intensive. Using special policy zones as indicators of falling offshoring costs, I demonstrate that falling offshoring costs contribute significantly to the growth in intrafirm offshoring share for industries with larger communication

[39] The division of cities into different regions is according to the official criteria, see http://www.stats.gov.cn/was40/gjtjj_detail.jsp?searchword=%B6%AB%B2%BF&channelid=7565&record=1.

intensity, but not for industries with lower communication intensity.

Another key result is that the presence of different organizational forms has important implications for the productivity effect identified in Grossman and Rossi-Hansberg (2008). Reductions in offshoring costs lead to decreased labor demand for each unit of task performed in MNCs and thus result in lower efficiency wages. On the other hand, the expansion in the range of tasks performed via intrafirm offshoring along with an expansion in home production leads to an increase in employment in MNCs which increases the efficiency wage. The net effect on the efficiency wage will determine whether the productivity gain becomes larger or smaller.

Finally, China is becoming a more and more important destination for offshoring. By studying the organization of offshoring in China, my work contributes to a broader understanding of offshoring patterns and their welfare implications. Furthermore, the framework presented here could also be used to study the effects of other interesting events. For example, one particularly important question is how technological upgrading in developing countries affects the relative prevalence of different organizational forms in developed countries. It also provides rich predictions for task trading. As a result, it should help motivate other empirical studies of the evolving system of world trade. For example, empirical studies of the extensive margin (change in the range of offshored tasks) and intensive margin (change in units of tasks performed) of offshoring could be areas for future research.

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Appendix

A Solving the Equilibrium

Rewrite equation (12) as

$$\begin{aligned}\hat{w}+\hat{\Omega} &= \hat{w}+\frac{1}{\Omega}\left(\frac{\partial\Omega}{\partial I_m}\left(\frac{\partial I_m}{\partial I_o}dI_o+\frac{\partial I_m}{\partial\beta}d\beta\right)+\frac{\partial\Omega}{\partial I_o}dI_o\right)\\ &= \hat{w}+\frac{1}{\Omega}\left(\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o}+\frac{\partial\Omega}{\partial I_o}\right)dI_o+\frac{\beta}{\Omega}\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta}\hat{\beta}=0. \qquad (21)\end{aligned}$$

Equation (8) suggests that, given w^* unchanged,

$$\begin{aligned}\hat{w} &= \hat{\beta}+\hat{t}\left(\frac{I_o}{K_m}\right)+\hat{t}\left(\frac{I_m}{K_a}\right)-\hat{t}\left(\frac{I_m}{K_m}\right)\\ &= \hat{\beta}+\frac{t'\left(\frac{I_o}{K_m}\right)}{t\left(\frac{I_o}{K_m}\right)K_m}dI_o+\frac{t'\left(\frac{I_m}{K_a}\right)}{t\left(\frac{I_m}{K_a}\right)K_a}dI_m-\frac{t'\left(\frac{I_m}{K_m}\right)}{t\left(\frac{I_m}{K_m}\right)K_m}dI_m\\ &= \hat{\beta}+\varepsilon\left(\frac{I_o}{K_m}\right)\frac{dI_o}{I_o}+\bar{\varepsilon}\frac{dI_m}{I_m}\\ &= \hat{\beta}+\varepsilon\left(\frac{I_o}{K_m}\right)\frac{dI_o}{I_o}+\frac{\bar{\varepsilon}}{I_m}\left(\frac{\partial I_m}{\partial I_o}dI_o+\beta\frac{\partial I_m}{\partial\beta}\hat{\beta}\right)\\ &= \left(1+\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial\beta}\beta\right)\hat{\beta}+\left(\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)+\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial I_o}\right)dI_o \qquad (22)\\ &= A\hat{\beta}+BdI_o,\end{aligned}$$

where $A\equiv 1+\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial\beta}\beta>0$, and $B\equiv\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)+\frac{\bar{\varepsilon}}{I_m}\frac{\partial I_m}{\partial I_o}>0$.

Equation (21) and (22) then slove the two unknowns dI_o and $\hat{w}$,

$$\begin{aligned}\hat{w} &= \frac{B\beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta}-A\left(\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o}+\frac{\partial\Omega}{\partial I_o}\right)}{\Omega B+\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o}+\frac{\partial\Omega}{\partial I_o}}\left(-\hat{\beta}\right), \qquad (23)\\ dI_o &= \frac{A\Omega+\beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta}}{\Omega B+\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o}+\frac{\partial\Omega}{\partial I_o}}\left(-\hat{\beta}\right). \qquad (24)\end{aligned}$$

To simplify the solutions, using the facts that

$$\begin{aligned}\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)\Omega+\frac{\partial\Omega}{\partial I_o} &= \frac{1-I_o}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right),\\ \frac{\bar{\varepsilon}}{I_m}\Omega+\frac{\partial\Omega}{\partial I_m} &= \frac{\bar{\varepsilon}}{I_m}\left(1-I_o+\frac{\int_{I_m}^{I_o}t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right),\\ \frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)\frac{\partial\Omega}{\partial I_m}-\frac{\bar{\varepsilon}}{I_m}\frac{\partial\Omega}{\partial I_o} &= \frac{\bar{\varepsilon}}{I_m}\frac{\varepsilon\left(\frac{I_o}{K_m}\right)}{I_o t\left(\frac{I_o}{K_m}\right)}\int_{I_m}^{I_o}t\left(\frac{i}{K_m}\right)di.\end{aligned}$$

I have

$$
\begin{aligned}
& B\beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta} - A\left(\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o} + \frac{\partial\Omega}{\partial I_o}\right) \\
= & \left(\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right) + \frac{\bar\varepsilon}{I_m}\frac{\partial I_m}{\partial I_o}\right)\beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta} - A\left(\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o} + \frac{\partial\Omega}{\partial I_o}\right) \\
= & \left(\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)\beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta} - A\frac{\partial\Omega}{\partial I_o}\right) + \left(\frac{\bar\varepsilon}{I_m}\frac{\partial I_m}{\partial I_o}\beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta} - A\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o}\right) \\
= & \left(\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)\frac{\partial\Omega}{\partial I_m} - \frac{\bar\varepsilon}{I_m}\frac{\partial\Omega}{\partial I_o}\right)\frac{\partial I_m}{\partial\beta}\beta - \frac{\partial\Omega}{\partial I_o} + \left(\frac{\bar\varepsilon}{I_m}\beta\frac{\partial I_m}{\partial\beta} - A\right)\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o} \\
= & \frac{\bar\varepsilon}{I_m}\frac{\partial I_m}{\partial\beta}\beta\frac{\varepsilon\left(\frac{I_o}{K_m}\right)}{I_o t\left(\frac{I_o}{K_m}\right)}\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di - \frac{\partial\Omega}{\partial I_o} - \frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o},
\end{aligned}
$$

$$
\begin{aligned}
& B\Omega + \frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial I_o} + \frac{\partial\Omega}{\partial I_o} \\
= & \left(\frac{1}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right)\Omega + \frac{\partial\Omega}{\partial I_o}\right) + \left(\frac{\bar\varepsilon}{I_m}\Omega + \frac{\partial\Omega}{\partial I_m}\right)\frac{\partial I_m}{\partial I_o} \\
= & \frac{1 - I_o}{I_o}\varepsilon\left(\frac{I_o}{K_m}\right) + \frac{\bar\varepsilon}{I_m}\frac{\partial I_m}{\partial I_o}\left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right),
\end{aligned}
$$

and

$$
\begin{aligned}
& A\Omega + \beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta} \\
= & \left(1 + \frac{\bar\varepsilon}{I_m}\frac{\partial I_m}{\partial\beta}\beta\right)\Omega + \beta\frac{\partial\Omega}{\partial I_m}\frac{\partial I_m}{\partial\beta} \\
= & \Omega + \left(\frac{\bar\varepsilon}{I_m}\Omega + \frac{\partial\Omega}{\partial I_m}\right)\frac{\partial I_m}{\partial\beta}\beta \\
= & \Omega + \frac{\bar\varepsilon}{I_m}\frac{\partial I_m}{\partial\beta}\beta\left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right)di}{t\left(\frac{I_o}{K_m}\right)}\right).
\end{aligned}
$$

Then the equilibrium solution (16) and (17) are derived.

The change of I_m can then be solved,

$$
\begin{aligned}
dI_m &= \frac{\partial I_m}{\partial I_o} dI_o + \frac{\partial I_m}{\partial \beta} d\beta \\
&= \frac{\Omega + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right)}\right) \frac{\bar{\varepsilon}}{I_m} \frac{\partial I_m}{\partial \beta} \beta}{\frac{1-I_o}{I_o} \varepsilon \left(\frac{I_o}{K_m}\right) + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right)}\right) \frac{\bar{\varepsilon}}{I_m} \frac{\partial I_m}{\partial I_o}} \left(-\hat{\beta}\right) \frac{\partial I_m}{\partial I_o} + \beta \frac{\partial I_m}{\partial \beta} \hat{\beta} \\
&= \left(\frac{\Omega \frac{\partial I_m}{\partial I_o} - \frac{1-I_o}{I_o} \varepsilon \left(\frac{I_o}{K_m}\right) \beta \frac{\partial I_m}{\partial \beta}}{\frac{1-I_o}{I_o} \varepsilon \left(\frac{I_o}{K_m}\right) + \left(1 - I_o + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right)}\right) \frac{\bar{\varepsilon}}{I_m} \frac{\partial I_m}{\partial I_o}} \right) \left(-\hat{\beta}\right).
\end{aligned}
$$

B Proof of Proposition 3

The range of tasks performed in arm's length offshoring (I_m) would decrease if and only if

$$
\begin{aligned}
& dI_m < 0 \\
\Leftrightarrow\ & \Omega \frac{\partial I_m}{\partial I_o} < \frac{1 - I_o}{I_o} \varepsilon \left(\frac{I_o}{K_m}\right) \beta \frac{\partial I_m}{\partial \beta} \\
\Leftrightarrow\ & \frac{\Omega}{\frac{1-I_o}{I_o} \varepsilon \left(\frac{I_o}{K_m}\right)} < \frac{\beta \frac{\partial I_m}{\partial \beta}}{\frac{\partial I_m}{\partial I_o}} = \frac{\beta \frac{\partial L_m}{\partial \beta}}{\frac{\partial L_m}{\partial I_o}} = \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right) + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{1-I_o}} \\
\Leftrightarrow\ & \varepsilon \left(\frac{I_o}{K_m}\right) > \frac{I_o}{(1 - I_o)} \frac{\Omega}{(1 - I_o)} \left(\frac{t\left(\frac{I_o}{K_m}\right)(1 - I_o)}{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di} + 1 \right).
\end{aligned}
$$

Notice that, $\frac{\Omega}{(1-I_o)} \left(\frac{t\left(\frac{I_o}{K_m}\right)(1-I_o)}{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di} + 1 \right) > 1$ since $\Omega > 1 - I_o = \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{\frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{1-I_o}} > \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right) + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{1-I_o}}$.

C Proof of Proposition 4

The intrafirm offshoring becomes more prevalent if and only if

$$
\begin{aligned}
& d\left(\frac{I_o - I_m}{I_m}\right) > 0 \\
\Leftrightarrow\ & I_m dI_o - I_o dI_m > 0 \\
\Leftrightarrow\ & \frac{dI_m}{dI_o} = \frac{\partial I_m}{\partial I_o} + \frac{\partial I_m}{\partial \beta} \frac{d\beta}{dI_o} < \frac{I_m}{I_o} < 1.
\end{aligned}
$$

Given that $\frac{\partial I_m}{\partial I_o} > 0$ and $\frac{\partial I_m}{\partial \beta} \frac{d\beta}{dI_o} < 0$, then it would be satisfied as long as $\frac{\partial I_m}{\partial I_o}$ is sufficiently small. Recall that $\delta\theta_j K_a = K_m$, $\frac{\partial(\zeta(I_m,\delta\theta_j))}{\partial(\delta\theta_j)} > 0$, and $\zeta\left(I_m, \delta\theta_j\right) \to \infty$ if $\theta_j \to \infty$, then if θ_j is sufficiently large, $\zeta\left(I_m, \delta\theta_j\right)$ would be sufficiently large and $\frac{\partial I_m}{\partial I_o}$ is sufficiently small according to equation (14).

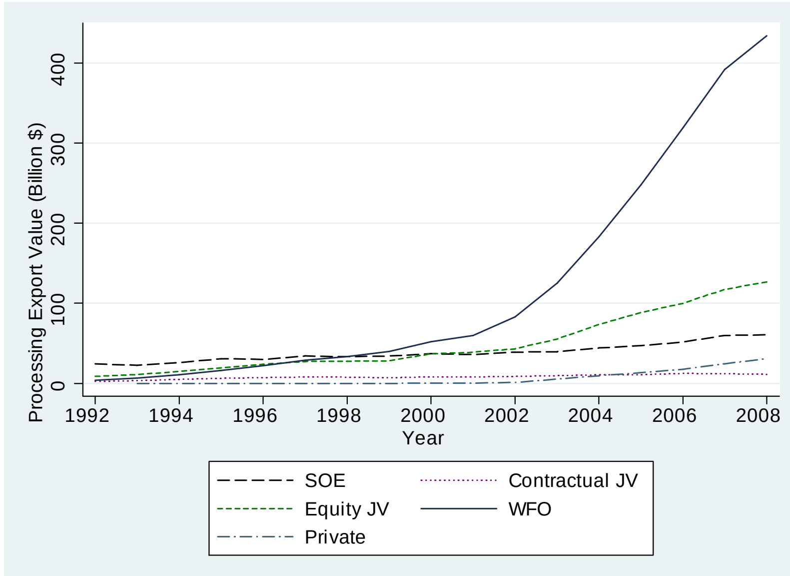

Figure 1: Export Processing Values of Different Types of Firms

Notes:

1. Firms' types are: SOE (State Owned Enterprise), Contractual JV (Contractual Joint Venture), Equity JV (Equity Joint Venture), WFO (Wholly Foreign Owned firms), and Private (Private owned firms).
2. Source: Author's calculation from the dataset.

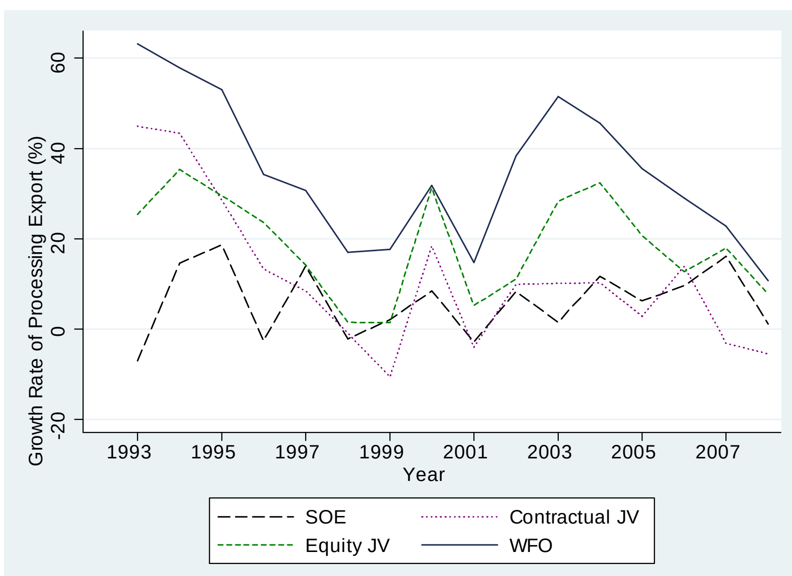

Figure 2: Growth Rate of Processing Export Value by Different Firms

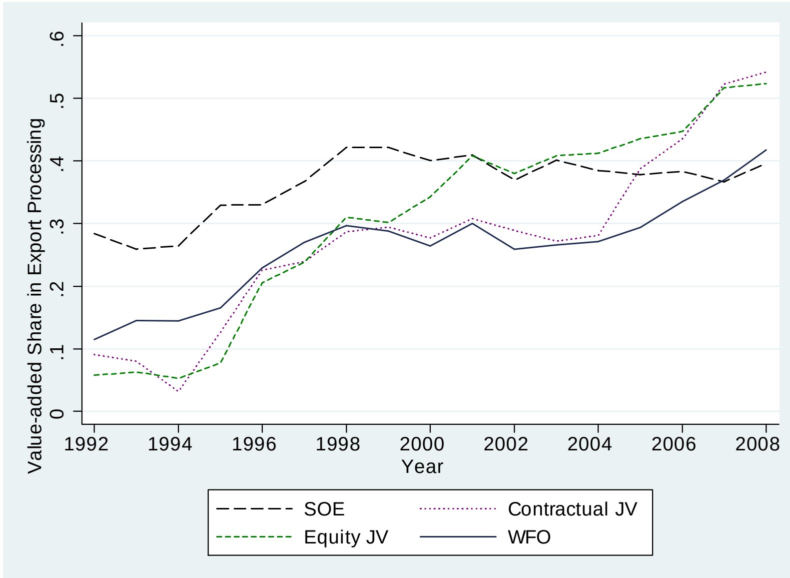

Figure 3: Value-added Share in Processing Export

Notes:

1. Firms' types are: SOE (State Owned Enterprise), Contractual JV (Contractual Joint Venture), Equity JV (Equity Joint Venture) and WFO (Wholly Foreign Owned firms).

2. Source: Author's calculation from the dataset.

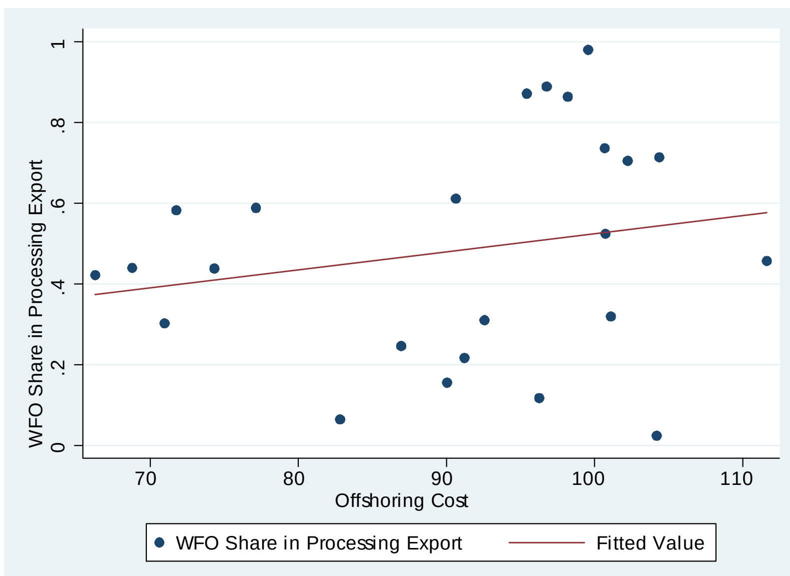

Figure 4: Offshoring Cost and WFO Share In Processing Tradeat

Notes:

1. Data are for 50 Economic and Technology Development Areas in China in 2007. The offshoring cost index is constructed by the sum of indexes of the cumulative investment in infrastructure, the capability of water, steam and gas supply, whether the administrative institution passes ISO9001 certification, whether the zone has authorities to approve provincial level foreign investment projects, whether the administrative management is efficient, and whether the zone has pent protection offices. WFO stands for Wholly-Foreign-Owned firms.

2. Source: Author's calculation based on China Development Zones Yearbook, 2007.

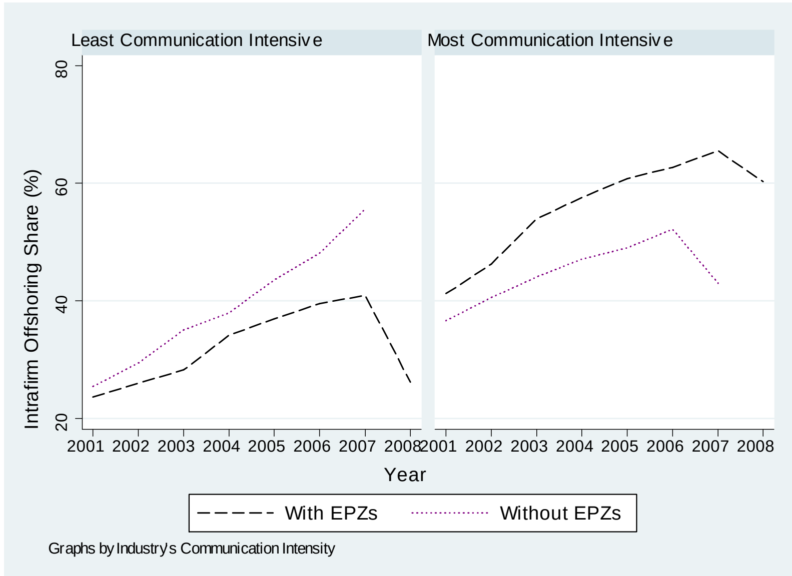

Figure 5: Communication Intensity and Impacts of Reductions of Offshoring Costs on Intrafirm Offshoring Share

Notes:

1. Communication intenstity is measured by the industry's requirement of capability of making decision and solving problem. Detailed construction of communication intensity is dicussed in section 3.

2. Least (or most) communication intensive industries in the graph are industries of first (or last) 25% observations when the data is sorted according to the communication intensity ascendingly, for example apparel industry (or computer industry).

3. EPZ stands for in cities with export processing zones.

4. Source: Author's calculation based on the dataset.

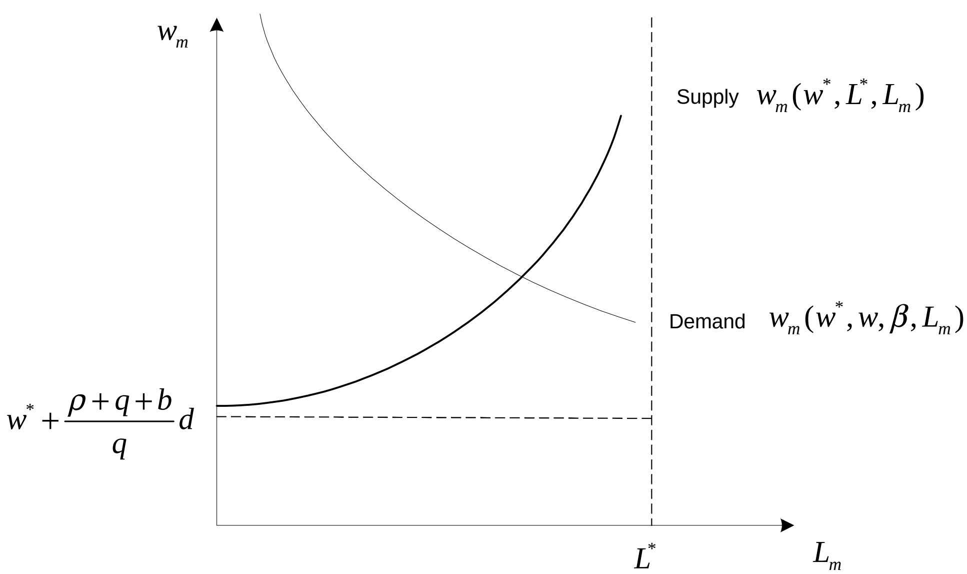

Figure 6: MNCs' Labor Market

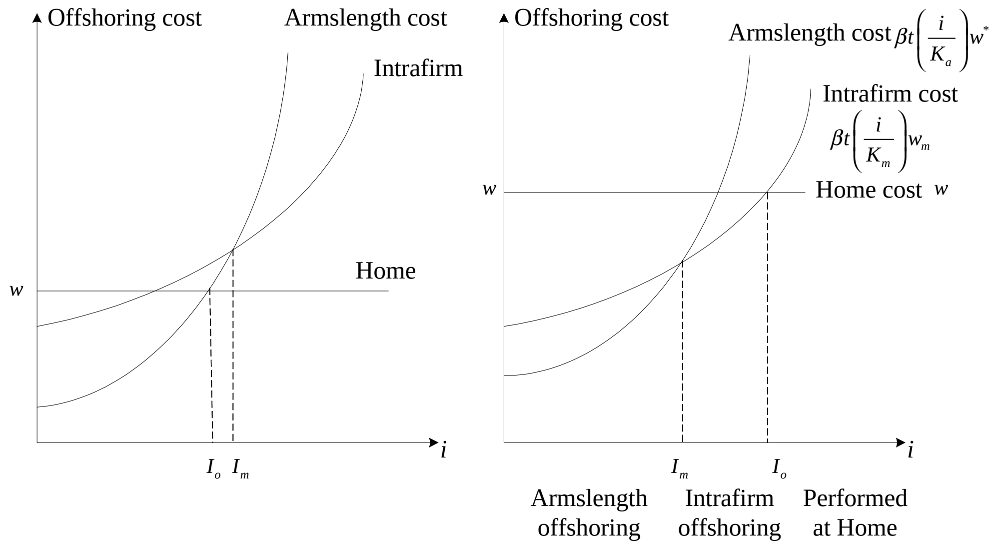

Figure 7: Task Offshoring in Different Organizational Forms

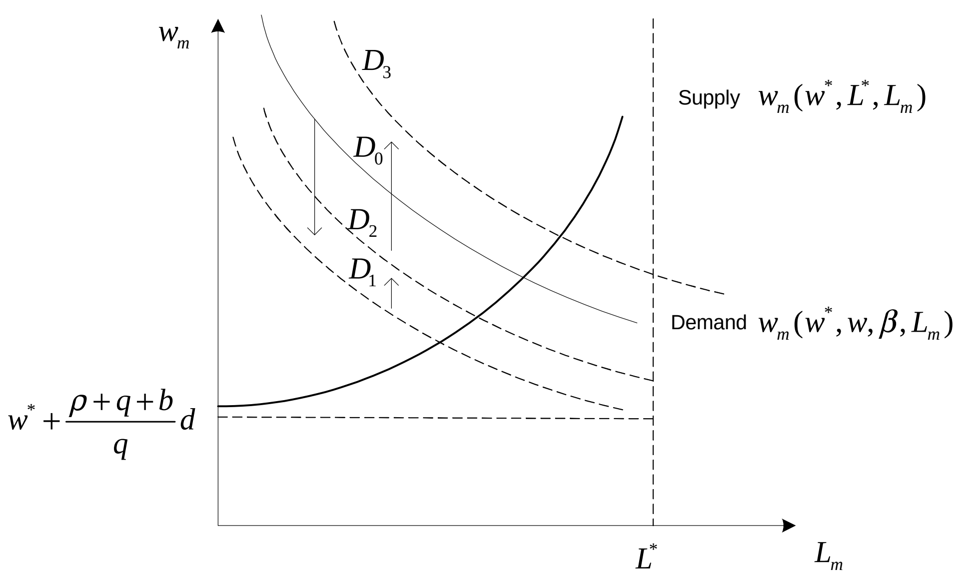

Figure 8: Effects of a Fall of Offshoring Cost on MNC Employment

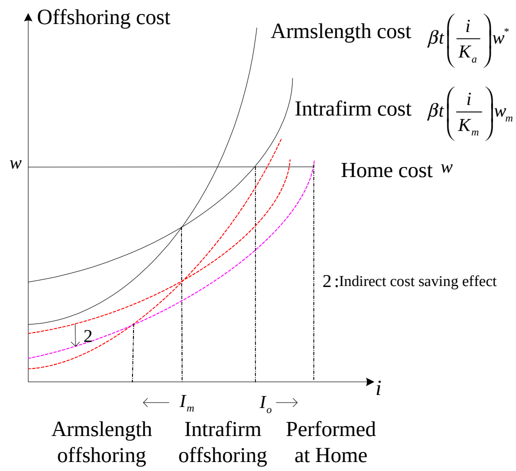

Figure 9: Indirect Cost Saving Effect Causes More Prevalent Intrafirm Offshoring

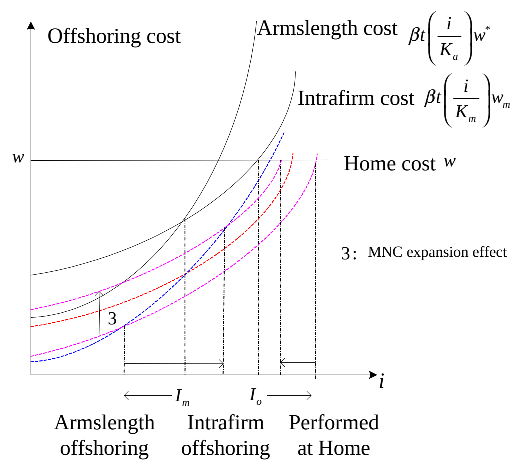

Figure 10: MNC Expansion Effect Causes Less Prevalent Intrafirm Offshoring

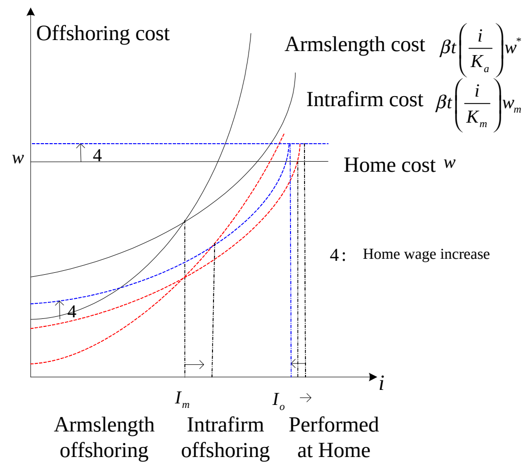

Figure 11: Home Wage Increase Causes Less Prevalent Intrafirm Offshoring

Table 1: Decomposing the Change of Processing Trade by WFO into Zones

Year	Export Change (Billion $)	Share of Export Change						Import Change (Billion $)	Share of Import Change					
		SEZ	ETDA	HTIDA	BA	EPZ	Non-zone		SEZ	ETDA	HTIDA	BA	EPZ	Non-zone
1998	4.89	-0.005	0.077	0.179	0.130		0.619	2.67	-0.012	0.174	0.290	0.185		0.363
1999	5.94	0.030	0.142	0.060	0.208		0.561	4.53	0.017	0.226	0.037	0.182		0.538
2000	12.6	0.093	0.121	0.107	0.067		0.611	10.2	0.087	0.179	0.138	0.071		0.525
2001	7.72	0.192	0.072	0.099	0.027		0.564	3.51	0.316	-0.031	0.085	0.014		0.506
2002	22.9	0.002	0.119	0.156	0.073	0.077	0.574	19.5	-0.001	0.076	0.154	0.130	0.089	0.552
2003	42.6	0.017	0.119	0.173	0.059	0.181	0.450	30.7	0.003	0.152	0.147	0.068	0.164	0.467
2004	57.2	0.021	0.187	0.100	0.050	0.184	0.459	40.9	0.025	0.227	0.083	0.029	0.142	0.494
2005	64.8	0.034	0.155	0.077	0.046	0.206	0.483	41.7	0.029	0.158	0.075	0.042	0.167	0.529
2006	71.7	0.044	0.091	0.021	0.081	0.262	0.501	37.6	0.026	0.122	0.000	0.062	0.201	0.589
2007	72.8	0.032	0.066	0.087	0.025	0.275	0.515	34.8	0.032	0.153	-0.008	0.001	0.171	0.650
2008	42.2	0.012	0.099	-0.253	-0.081	0.585	0.637	5.68	0.028	0.528	-0.812	-0.208	0.881	0.578

Note 1: Export change is culculated by processing export value in the current year minus that in the previous year. Similar for Import change. All values are nominal.

Note 2: Shares of the zones are culculated by the change of processing export(or import) value in the zone devided by the overall change of processing export(or import) in the same year.

Note 3: SEZ: Special Economic Zone; ETDA: Economic and Technology Development Area; HTIDA: Hi-Technology Industry Development Area; BA: Bonded Area; EPZ: Export Processing Zone; Non-zone: none of above area.

Note 4: Source: author's calculation from the dataset.

Table 2: Most to Least Communication Intensive Industries

NAICS	Industry
3361	Motor Vehicle Manufacturing
3341	Computer and Peripheral Equipment Manufacturing
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
3364	Aerospace Product and Parts Manufacturing
3342	Communications Equipment Manufacturing
3346	Manufacturing and Reproducing Magnetic and Optical Media
3254	Pharmaceutical and Medicine Manufacturing
3344	Semiconductor and Other Electronic Component Manufacturing
3333	Commercial and Service Industry Machinery Manufacturing
3251	Basic Chemical Manufacturing
...	...
3159	Apparel Accessories and Other Apparel Manufacturing
3141	Textile Furnishings Mills
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing
3162	Footwear Manufacturing
3379	Other Furniture Related Product Manufacturing
3152	Cut and Sew Apparel Manufacturing
3117	Seafood Product Preparation and Packaging
3116	Animal Slaughtering and Processing
3113	Sugar and Confectionery Product Manufacturing
3118	Bakeries and Tortilla Manufacturing

Table 3: Basic Statistics for Key Variables

Variables	Obs.	Mean	Std.Dev.	Min	Max
WFO share of processing export*100 ($Intrashare$)	431281	37.465	44.602	0	100
WFO share of processing export by FIEs*100 ($IntrashareFIE$)	328265	57.359	46.072	0	100
WFO share of processing export outside special policy zones*100 ($Intrashareoutzone$)	384758	34.702	43.833	0	100
EPZ Dummy	431281	0.275	0.447	0	1
Communication intensity ($cintense$)	394481	0.274	0.092	0	1
HT Dummy	431281	0.672	0.469	0	1
Non-agriculture population in million persons (NAP)	427741	2.592	2.561	0.120	11.969
Number of secondary school students in million persons (NSS)	425427	0.323	0.206	0.000	2.305
Proxy of transportation Infrastructure (Passenger number/population, $Trans$)	429889	34.527	41.898	1.890	285.830

Table 4: Main Estimation Results, $Intrashare$ as Dependent Variable

Model	Basic Model		Random Trend	
Estimation Method	Within	FD	Within	FD
	(1)	(2)	(3)	(4)
EPZ Dummy (EPZ)	-6.019***	-1.604	-1.050	-0.935
	(1.681)	(1.182)	(1.105)	(1.163)
$EPZ * cintense$	11.28*	10.97**	9.009**	9.011**
	(6.176)	(4.555)	(4.215)	(4.148)
HT Dummy (HT)	2.541*	2.523*	2.560*	2.451
	(1.526)	(1.388)	(1.310)	(2.016)
Nonagriculture population (NAP)	2.080**	4.672***	3.761***	4.350***
	(0.948)	(0.741)	(0.749)	(0.748)
Secondary school student (NSS)	13.78*	12.71	7.680	2.642
	(8.281)	(8.288)	(6.733)	(5.370)
Transportaion Infrastructure ($Trans$)	0.0417*	0.106***	0.0827***	0.102***
	(0.0215)	(0.0178)	(0.0179)	(0.0185)
Constant	14.55***		0.509	
	(3.803)		(0.327)	
Prod-City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Prod-City trend	No	No	Yes	Yes
Observations	385923	291333	291333	228003
Product-City Pairs	92108		63323	
Within R-square	0.083	0.014	0.003	0.002

1: Cluster robust standard errors at city level are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. 2: Dependent variable: Intrashare, calculated by WFOs' processing exports devided by overall processing exports, then times 100. 3: Regressors are export processing zone dummy(EPZ), interaction term of $EPZ * cintense$, other special zone dummy (HT), nonaggreculture population in million persons (NAP), number of students in secondary school in million persons (NSS) and transportaion infrastructure ($Trans$, calculated as the ratio of passenger number to population). 4: Estimation methods: FE: Fixed effect panel estimation; FD: First Differencing panel estimation.

Table 5: Predicted change of Intrafirm Offshoring Share

Year	Weighted Average of Communication Intensity	Weighted Average of Intrafirm Offshoring Share(%)	Predicted Percentage Increase of Intrafirm Offshoring Share (%)
1997	0.274102	27.568	5.14867
1998	0.28794	30.3509	5.087327
1999	0.291045	32.6892	4.809016
2000	0.295017	34.9111	4.605438
2001	0.301966	38.6449	4.322479
2002	0.323218	44.2246	4.210047
2003	0.356737	49.9343	4.333387
2004	0.353906	53.9742	3.961785
2005	0.349165	58.447	3.585517
2006	0.34351	61.4782	3.325861
2007	0.441582	62.2684	4.702559

Table 6: Intrafirm Offshoring Share of Export Processing by FIEs, $IntrashareFIE$ as Dependent Variable

Model	Basic Model		Random Trend	
Estimation Method	Within	FD	Within	FD
	(1)	(2)	(3)	(4)
EPZ Dummy (EPZ)	-4.377**	-1.458	-1.419	-2.280
	(2.202)	(1.447)	(1.542)	(1.800)
$EPZ * cintense$	4.391	10.97**	10.35**	12.27**
	(6.988)	(4.960)	(4.912)	(5.185)
HT Dummy (HT)	6.508***	4.980***	4.687***	4.795***
	(1.841)	(0.651)	(0.508)	(0.523)
Nonagriculture population (NAP)	2.648**	4.350***	3.274***	3.633***
	(1.315)	(0.939)	(0.808)	(0.772)
Secondary school student (NSS)	10.99	8.301	3.392	0.0280
	(9.313)	(6.916)	(4.570)	(4.377)
Transportaion Infrastructure ($Trans$)	0.0663**	0.0990***	0.0714***	0.0821***
	(0.0259)	(0.0227)	(0.0196)	(0.0192)
Constant	27.48***		1.955***	
	(4.996)		(0.301)	
Prod-City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Prod-City trend	No	No	Yes	Yes
Observations	294269	217030	217030	167374
Product-City Pairs	69202		47400	
Within R-square	0.102	0.015	0.002	0.002

1: Cluster robust standard errors at city level are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. 2: Dependent variable: $IntrashareFIE$, calculated by WFOs' processing exports devided by total processing exports by FIEs, then times 100. 3: Regressors are export processing zone dummy(EPZ), interaction term of $EPZ * cintense$, other special zone dummy (HT), nonaggreculture population in million persons (NAP), number of students in secondary school in million persons (NSS) and transportaion infrastructure ($Trans$, calculated as the ratio of passenger number to population). 4: Estimation methods: FE: Fixed effect panel estimation; FD: First Differencing panel estimation.

Table 7: Intrafirm Offshoring Share in Cities with Other Special Zones, *Intrashare* as Dependent Variable

Model	Basic Model		Random Trend	
Estimation Method	Within	FD	Within	FD
	(1)	(2)	(3)	(4)
EPZ Dummy (EPZ)	-5.228***	-1.000	-0.886	-0.738
	(1.880)	(1.221)	(1.107)	(1.183)
$EPZ * cintense$	11.69*	10.44**	8.790**	8.522*
	(6.359)	(4.714)	(4.379)	(4.286)
Nonagriculture population (NAP)	1.510	4.940***	4.702***	5.276***
	(1.360)	(1.287)	(1.476)	(1.301)
Secondary school student (NSS)	6.059	6.472	4.790	0.640
	(9.757)	(6.795)	(5.479)	(4.248)
Transportaion Infrastructure ($Trans$)	0.183*	0.113	0.0460	0.0812
	(0.0980)	(0.0767)	(0.0655)	(0.0595)
Constant	16.88***		1.609***	
	(5.864)		(0.370)	
Prod-City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Prod-City trend	No	No	Yes	Yes
Observations	259125	201039	201039	160395
Product-City Pairs	58057		41389	
Within R-square	0.074	0.013	0.003	0.002

1: Cluster robust standard errors at city level are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. 2: Dependent variable: Intrashare, calculated by WFOs' processing exports devided by overall processing exports, then times 100. 3: Regressors are export processing zone dummy(EPZ), interaction term of $EPZ * cintense$, nonaggreculture population in million persons (NAP), number of students in secondary school in million persons (NSS) and transportaion infrastructure ($Trans$, calculated as the ratio of passenger number to population). 4: Estimation methods: FE: Fixed effect panel estimation; FD: First Differencing panel estimation.

Table 8: Intrafirm Offshoring Share in East Region, $Intrashare$ as Dependent Variable

Model	Basic Model		Random Trend	
Estimation Method	Within	FD	Within	FD
	(1)	(2)	(3)	(4)
EPZ Dummy (EPZ)	-6.201***	-1.442	-0.917	-0.846
	(1.684)	(1.218)	(1.140)	(1.197)
$EPZ * cintense$	10.41	10.47**	8.763**	8.890**
	(6.339)	(4.699)	(4.317)	(4.250)
HT Dummy (HT)	2.824	3.911***	3.925***	4.260***
	(1.746)	(0.721)	(0.501)	(1.338)
Nonagriculture population (NAP)	1.601	4.577***	3.707***	4.333***
	(0.972)	(0.755)	(0.752)	(0.762)
Secondary school student (NSS)	15.32*	13.33	7.630	2.443
	(8.791)	(8.934)	(7.052)	(5.553)
Transportaion Infrastructure ($Trans$)	0.0311	0.103***	0.0811***	0.102***
	(0.0215)	(0.0182)	(0.0180)	(0.0189)
Constant	16.30***		0.577*	
	(4.129)		(0.344)	
Prod-City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Prod-City trend	No	No	Yes	Yes
Observations	355208	271668	271668	214630
Within R-squared	0.086	0.015	0.003	0.002
Product-City Pairs	81058		57031	

1: Cluster robust standard errors at city level are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. 2: Dependent variable: Intrashare, calculated by WFOs' processing exports devided by overall processing exports, then times 100. 3: Regressors are export processing zone dummy(EPZ), interaction term of $EPZ * cintense$, other special zone dummy (HT), nonaggreculture population in million persons (NAP), number of students in secondary school in million persons (NSS) and transportaion infrastructure ($Trans$, calculated as the ratio of passenger number to population). 4: Estimation methods: FE: Fixed effect panel estimation; FD: First Differencing panel estimation.

Table 9: Appendix Table A: Main Notation for the Paper

Symbol	Definition
	Panel A: Theoretical Framework
a_{Lj}, a_{Hj}	Units of low-skilled (high-skilled) labor used to perform L-tasks (H-tasks) to produce one unit of output j
i	Complexity level of task indexed by i
K_m, K_a	Number of words used in communication by MNCs and armslength suppliers
$t(z)$	Diagnosis cost for a word referring to an interval of length z
β	Communication technology
δ	The inferiority of communication in armslength offshoring
w, w^*, w_m	Home and foreign low-skilled labor wage, and low-skilled wage paid by MNCs
b	Natural exogenous quit rate from MNCs
q	The rate at which shirking is detected in MNCs
e	The accession rate of non-MNC workers aquiring MNC jobs
V_{mn}, V_{ms}, V_a	The expected lifetime utility of non-shirking MNC employees, shirking MNC employees, and non-MNC workers
ρ	The discount rate
d	Disutility of not shirking
L, L^*, L_m	Home and foreign low-skilled labor, and low-skilled labor hired by MNCs
I_o	The marginal offshored task
I_m	The marginal offshored task in the form of intrafirm offshoring
$\varepsilon(z)$	The elasticity function of t function
$\bar{\varepsilon}$	$\bar{\varepsilon}$ is defined as by $\bar{\varepsilon} \equiv \varepsilon\left(\frac{I_m}{K_a}\right) - \varepsilon\left(\frac{I_m}{K_m}\right)$
$\zeta(I_m, \delta\theta_j)$	$\zeta(I_m, \delta\theta_j) = \partial\left(\frac{t\left(\frac{I_m}{K_a}\right)}{t\left(\frac{I_m}{K_m}\right)}\right) / \partial I_m = \frac{t\left(\frac{I_m}{K_a}\right)\bar{\varepsilon}}{t\left(\frac{I_m}{K_m}\right) I_m}$
p	Price of good Y when good X is numeraire
$\Omega(I_o, I_m)$	$\Omega(I_o, I_m) \equiv (1 - I_o) + \frac{1}{t\left(\frac{I_o}{K_m}\right)} \frac{t\left(\frac{I_m}{K_m}\right)}{t\left(\frac{I_m}{K_a}\right)} \int_0^{I_m} t\left(\frac{i}{K_a}\right) di + \frac{\int_{I_m}^{I_o} t\left(\frac{i}{K_m}\right) di}{t\left(\frac{I_o}{K_m}\right)}$
x, y	Quantity of good X and Y
s, s^*	Home and foreign high-skilled labor wage
H, H^*	Home and foreign high-skilled labor
A^*	Hicks-neutral technological inferiority of foreign firms
$D(p)$	The (homothetic) world relative demand for good Y
A, B	$A \equiv 1 + \frac{\bar{\varepsilon}}{I_m} \frac{\partial I_m}{\partial \beta} \beta > 0$, and $B \equiv \frac{1}{I_o} \varepsilon\left(\frac{I_o}{K_m}\right) + \frac{\bar{\varepsilon}}{I_m} \frac{\partial I_m}{\partial I_o}$
	Panel B: Empirical Specification
ε_{jct}	Idiosyncratic error term, $\varepsilon_{ict} \sim N\left(0, \sigma_c^2\right)$
α_{jc}	Product-city fixed effect
α_t	Year fixed effect
g_{jc}	Product-city specific trend
λ_t	Year fixed effect, equal to $\alpha_t - \alpha_{t-1}$