Essays on Firms' Behavior in International Trade with Vertical Specialization

Madhura Maitra

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ABSTRACT

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My dissertation consists of three essays that allow me to investigate two related trade induced economic phenomena — processing trade and offshoring — using diverse datasets and theory. In Chapter 1, a joint work with Mi Dai and Miaojie Yu from Peking University, we solve the documented puzzle that exporters in China are less productive than non-exporters in the labor intensive sectors and in the Foreign Invested Enterprises (FIE). We show that this anomalous finding is entirely driven by firms that engage only in export processing — the activity of assembling tariff exempted imported inputs into final goods for resale in the foreign markets. We find that pure processing exporters are less productive than non-exporters, but other types of exporters — those doing only non-processing trade and those doing both processing and non-processing trade — have superior performance relative to non-exporters. Our results show that distinguishing between processing and ordinary exporters is crucial for understanding firm-level exporting behavior in China. In Chapter 2, a joint work with Henrik Bursland Fosse, from Copenhagen Business School, we investigate the effects of offshoring on wages. Offshoring firms are found to pay higher average wages than purely domestic firms. We provide a unifying empirical approach by capturing the different channels through which offshoring may explain this wage

difference: (i) due to a change in the composition of workers (skill composition effect) (ii) because all existing workers get higher pay (rent sharing effect). Using Danish worker-firm data we explain how much each channel contributes to higher wages. To estimate the causal effect of offshoring on wages we use China's accession to the WTO in December 2001 and the soon after boom in Chinese exports as positive exogenous shocks to the incentive to offshore to China. Both skill composition and rent sharing effects are found to be important in explaining the resultant gain in wages. We also show that the firm's timing in the offshoring process determines the relative importance of a channel. For firms offshoring to China in 2002 but not in 1999, only rent sharing explains the gain in wages. However, for firms offshoring to China both before and after China's WTO accession the wage increase is explained more by the skill composition effect. Moreover, these patterns are not discernable from the measures of skill composition and rent sharing available in typical firm level datasets— such as ratio of educated to uneducated workers and sales per employee. In Chapter 3, I extend the Sethupathy (2008) model to investigate the wage effects of offshoring in the presence of heterogeneous firms, heterogeneous workers, and imperfections in the labor market with rent sharing. The salient features of the model are: first, there are heterogeneous firms who differ in terms of productivity; second, presence of heterogeneous workers who vary at the skill level; third, imperfect labor market with presence of search costs, wage bargaining leading to rent sharing between firms and workers; fourth, performance of high-skilled and low-skilled tasks are required for production of the good; fifth, there is opportunity for offshoring each type of task, requiring a marginal cost that varies with the degree of non-routineness of the task and a fixed cost. In this framework I show that a fall in the cost of offshoring increases average wage in the offshoring firm due to a rent sharing effect. This effect can be further reinforced or weakened by an accompanying skill composition effect. Average wages in the non-offshoring firms decline due to a rent sharing effect only; there is no skill composition effect for these firms in the model.

Contents

List of Tables

List of Figures

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To Baba, Ma, and Shubro

Chapter 1

Unexceptional Exporter Performance in China? The Role of Processing Trade[1]

1.1 Introduction

The nature of international trade has changed — as Grossman and Rossi-Hansberg (2006) put it: "It's not wine for cloth anymore". In the modern world, with rapid progress of communication and technology, production processes increasingly involve global supply chains spanning multiple countries, with different stages of the production taking place in several disparate locations. A particular form of this fragmented production technique is processing trade: the activity of assembling tariff exempted imported inputs into final goods for resale in the foreign markets. The iPhone is a classic example: the different components of an iPhone are manufactured in Japan, Korea, Germany, US, and Taiwan from where these are shipped to China for the final assembly at Foxconn, an exclusive iPhone assembler located in Shenzhen,

[1] **This Chapter is written jointly with Mi Dai and Miaojie Yu from the Peking University.**

China. All final assembled products are exported back to the US and other markets (Xing, 2011). In terms of its sheer magnitude processing trade in China merits special attention. Processing trade accounts for nearly half of China's exports, exceeding total exports for most countries except Germany and USA. Processing / assembly has become popular in other developing countries. In 2006, 130 countries had established 3500 Export Processing Zones (EPZs), which employed 66 million people in total. For many countries (Kenya, Malaysia, Argentina, etc.), exports from EPZs accounted for over 80 percent of their total exports (International Labor Office, 2007).

To the best of our knowledge, this paper is one of the first to study the performance of processing firms vis-à-vis non-processing ones. We demonstrate that processing exporters in China are fundamentally different from the traditional exporters, who are found to be exceptional performers for a wide range of countries and measures. Most studies analyzing exporter behavior in China fail to distinguish between the two[2]; however we show that accounting for this difference is crucial. In fact, if all exporters are treated the same in China, a puzzling result emerges: contrary to the accumulated evidence in the literature, exporters are no longer superior performers (documented by Lu et al., 2010 and Lu, 2010). We show that this finding is entirely driven by processing exporters. Other types of exporters — those doing only non-processing trade and those doing both processing and non-processing trade — have the usual superior performance relative to non-exporters.

In this paper we merge the Chinese Manufacturing Survey data, which provides all firm level information (except firms' processing status), with the Chinese Customs data, which allows us to distinguish firms according to whether or not they engage in processing trade. Our main findings are: (1) processing exporters are less productive than both non-processing exporters and non-exporters. (2) It is crucial to account for processing trade separately. Once processing exporters are accounted for,

[2]Papers like Park et al. (2010), Yang and Mallick (2010), Girma et al. (2009), Lu et al. (2010, 2011), Lu (2010) do not distinguish between processing and non-processing exporters — exceptions being Yu (2011), Manova and Zhang (2011).

the productivity abnormalities documented in previous research (Lu et al., 2010 and Lu, 2010) are eliminated or alleviated. (3) Processing exporters have the lowest profits per worker, pay lowest wages per worker, have lowest price per unit of exports, are relatively smaller in terms of sales, and have lower capital intensity. Moreover, processing exporters are concentrated in labor intensive sectors and in Foreign Invested Enterprises (henceforth FIE).

Our results show that not only are processing exporters consistently performing worse than non-processing exporters, but failing to consider the two types of exporters separately make performance of exporters appear worse than non-exporters – even though non-processing exporters' performance is similar to what has been widely documented in the literature. It is thus essential to treat processing and non-processing exporters separately; and henceforth, studies of export performance in China (or countries with large processing trade sectors such as Mexico and Vietnam) should account for this distinction.

We investigate possible explanations behind low productivity of processing exporters. The theories are classified into two groups: (1) Processing exporters are actually less productive. (2) Processing exporters may appear less productive in the data due to measurement issues, for example, if their pricing policy leads to lower revenue or value added which gets translated into lower revenue based productivity measures. The mechanism consistent with the first idea is that processing trade is a different activity compared to ordinary trade. Our data shows that processing exporters are different in all dimensions. These exporters are the least profitable, pay lowest wages per worker — indicating that they hire relatively unskilled labor, and are less capital intensive. We also find that processing firms have lowest price per unit of export. This is consistent with the idea that the products exported by them are different (for example, low quality products which fetch lower price and revenue and yields lower profits) than those exported by the other exporters. Given that processing firms pay lower fixed cost[3] it makes sense that only the low productive firms would select into processing trade.

Mechanisms consistent with the second idea are as follows: first, transfer pricing by foreign owned processing exporters can make them appear less productive, a result much less pronounced in non-foreign firms where processing exporters are no less productive than non-exporters. Our data provides mixed evidence for the hypothesis that transfer pricing leads to low productivity of foreign owned processing exporters. Second, processing trade firms receive contracts from foreign firms to produce the final product. However, the foreign firm owns the patent or blue print of the product and can squeeze the processing exporters' markup and make them behave as price takers — this can lead to lower revenue and hence low measured productivity. Controlling for market power (levels of export, firm size, markup and industry market share are used as proxies for market power) in the baseline regression does not alter our main result. Thus low market power is not driving the low productivity of these firms. In summary, our results imply that processing trade involves unskilled labor intensive jobs having low profitability and production of low quality goods. The fact that processing firms receive govt. tax benefits implies that processing activity has lower fixed cost. This means that low productive firms select into doing only processing trade whereas high productive firms would do both processing and non-processing trade. The productivity ranking of different types of exporters in our data supports this hypothesis.

Our paper is related to the firm level trade literature analyzing the behavior of exporters. It is closely related to two papers documenting counter-Melitz findings in Chinese exporters. The first paper by Lu et al. (2010), shows that the anomalous result is true only for firms with foreign investments. The second one by Lu (2010) finds that exporters are less productive than non-exporters only in labor intensive

[3]Fixed cost is lower for processing exports since: (i) the foreign buyer is responsible for marketing and distribution of the final processed product, and (ii) the government offers easier customs clearance procedures for processing trade in EPZs.

sectors. Their explanations do not take into account the role of processing trade. Here we match the firm level data used in the two prior works to the Chinese customs data[4]. The merged data can replicate the prior results; but more importantly it allows us to identify a firm's processing status. We show that the fundamental distinction that matters for the counter-Melitz result is neither foreign investment nor labor intensity, but rather participation in processing trade; because processing exporters are least productive.

This paper is also related to the literature studying global supply chains since processing trade is a special form of vertical specialization. Though many papers, both theory and empirical, have studied vertical specialization and supply chains (Feenstra and Hanson, 1996; Hummels et al., 1998; Hummels et al., 2001; Yi , 2003; Feenstra and Hanson, 2005; Hanson et al., 2005; Grossman and Rossi-Hansberg, 2008; Costinot et al., 2011; Johnson and Noguera, 2011, etc.), none of these papers have investigated the agents who are the conduits of supply chains from a developing country's point of view — we fill this gap. Lastly, our work is closely related to the literature documenting the special nature of processing trade. Bergin et al. (2008), show that processing industries in Mexico (Maquiladora) are subject to higher volatility. The paper by Koopman et al. (2008) shows that using traditional methods for calculating value added for countries that actively engage in processing trade can overestimate the domestic content of these countries' exports. Yu (2011) shows that due to input tariff exemption policy on processing trade, the effect of input tariff reduction on firm productivity is small in China. We show that processing exporters are less productive, and account for the abnormal productivity of Chinese exporters. Our results imply that an increase in processing firms has re-allocation effects opposite to the Melitz (2003) prediction — it reduces average productivity of the sector.

The paper is organized as follows. Section 2 describes the data. Section 3

[4]The firm level data does not provide any information about the firms' processing status. This information is available from the customs data; hence using the merged data is crucial.

provides several stylized facts about processing exporters in China and relates them to the productivity abnormality documented about Chinese exporters. Section 4 provides discussion about possible theories that explain processing exporters' unexceptional performance and how well they are supported by the data. The last section concludes.

1.2 Data

1.2.1 Firm Level Data

The firm level data in this paper comes from Annual Surveys of Manufacturing Firms conducted by the National Bureau of Statistics of China from 2000 to 2005. The survey includes all State Owned Enterprises (SOE) and those Non-State Owned Enterprises with annual sales of five million yuan (about 650,000 US dollars) or more. The dataset includes information from balance sheet, profit and loss and cash flow statements of firms, includes about 80 variables, and provides detailed information on firm's identification, ownership, export status, employment, capital stock, revenue, which are of particular use in this paper. These firms contribute about 98% of total Chinese manufacturing exports in the aggregate trade data. To clean the data, following Feenstra et al. (2011), we drop observations that report missing or negative values for any of the following variables: total sales, total revenue, total employment, fixed capital, export value, intermediate inputs, if export value exceeds total sales or if share of foreign asset exceeds one. We include firms with at least eight employees. However, this data provides no information about a firm's processing status.

1.2.2 Transactions Level Customs Data

The transactions level customs data comes from China's General Administration of Customs and spans from 2000-2005. It contains disaggregate product level information of firms' trading price, quantity and value at the HS8 digit level. Importantly, this data provides information on whether a transaction was processing or not — we construct firms' processing status from this dataset. We divide exporting firms into three types depending on their nature of transactions in a given year: (1) processing firms: who only engage in processing transactions; (2) non-processing firms: who only make non-processing transactions; (3) both: if a firm makes both processing and non-processing transactions.

1.2.3 Combining the Two Datasets

Combining the firm level data with the transactions level data is problematic because the firm identifiers used in the two datasets are different — a nine digit id in the firm level data vs. an eleven digit id in the customs data, with no common elements. Following Yu (2011), we merge the two datasets by using zip codes and the last seven digits of a firm's phone number. The details of the merge variables are provided in Appendix A.1. We are able to merge about 30% of the exporters in the firm level data with the transactions data. One possible issue is selection, since we lose quite a few exporters[5]. Table 1.1 shows the comparison of exporters in the firm level data that could be matched with the customs data to those that could not be matched. We see that the merged exports look slightly bigger on average compared to the unmerged exporters. Moreover we show in the Appendix B.1 that the merged data can replicate the counter Melitz finding documented in the previous literature. Table A.1 shows that exporters are less productive than non-exporters within foreign owned firms. Table 1.6a shows that in terms of value added per worker, exporters

[5]We have run all our regressions using only the firm level data by dividing exporters into two types: regular exporters (who sell domestically as well as export) and pure exporters (who only export). We find that pure exporters are highly correlated with processing exporters and that pure exporters are the least productive. The reason we prefer to use the merged data is that we find around 30% of pure exporters are doing non-processing trade only, and they are not less productive than non-exporters. This result implies that the processing status (as opposed to export intensity) of a firm is crucial in determining its productivity.

are less productive in the labor intensive sectors. However in Table A.2b using value added per worker as our dependant variable and controling for size and in Table A.2c using TFP (Olley-Pakes) measures we find no such evidence[6]. One explanation for the difference in results when using the two different productivity measures without controlling for size could be that value added per worker ignores the role of capital but is sensitive to capital intensity. Thus higher capital intensity mechanically leads to higher value added per worker.

1.3 Stylized Facts about Processing Exporters

1.3.1 China's Export-Processing Regime

The Chinese government has been actively promoting export processing since the 1980s. There are altogether 16 specific types of processing trade in China, but two of them are more common: processing with supplied materials (henceforth PWSM) and processing with imported materials (henceforth PWIM)[7]. For PWSM, a Chinese firm obtains raw materials and parts from its foreign trading partners without making any payments. After processing/assembly, the product is sold back to the firm who provided the parts and materials. The processing firm only charges a processing fee on the foreign firm[8]. By contrast, for PWIM, the Chinese firm pays for the imported materials. It also has the freedom to choose the export destination of the

[6]Similar results are also obtained when we use firm level data only.

[7]PWSM also refers to "pure assembly" in Feenstra and Hanson (2005) and "processing with assembly" as adopted in Yu (2011). Correspondingly, PWIM is also called "input and assembly" and "processing with inputs".

[8]The measurement of TFP for PWSM firms is problematic since they do not report value of the intermediate inputs supplied from abroad in their accounting statements and the output value reported is not the total value of the final output but just the processing fee charged. However, PWSM firms account for less than 5% of all exporters in our data and separating exporters by their detailed processing status shows that both pure PWSM and pure PWIM exporters are less productive than non-exporters (tables not reported). This alleviates the worry that bias in measuring TFP for PWSM firms is driving our result.

final processed product.

Export processing in China is subject to very different policy treatment compared to non-processing trade. First, processing activities enjoy favorable taxation. The amount of imported inputs actually used in the making of the finished products for export is exempt from tariffs and import-related taxes. All processed finished products for export are also exempt from export tariffs and value-added tax[9]. Second, the finished products using the tax-exempted materials have to be re-exported, and enterprises are not allowed to sell the tax-exempted materials and parts or finished products in China[10, 11].

Although processing trade is defined as importing materials and re-exporting the finished products, it should be noted that not all transactions that involve importing and re-exporting are treated as processing trade. A transaction is recorded as processing/assembly by the Customs, and taxes are exempt (or rebated) only if a firm with legal processing status declares the transaction to be processing. In order to get processing status, a firm needs to: first, obtain the Processing Trade Approval Certificate from the Commerce Authorities; and second, should then present the Processing Trade Approval Certificate and Processing Trade Contract to the Customs Office where the processing firm is located to complete the filing and registration formalities and to apply for the Processing Trade Registration Handbook. A transaction will be recorded as processing only if a firm declares it to be processing to the Customs by filling out the registration handbook.

[9]The taxation policy for PWSM and PWIM are slightly different. For PWSM, import and output tariffs are never levied, for PWIM, however, tariffs on the imported materials are first levied, but then rebated to the firm upon re-exporting of the final products.

[10]If such goods have to be sold in the domestic market for special reasons, approval must be obtained from the commerce authorities in charge of processing trade at the provincial level as well as the Customs authorities. If approved to sell domestically, the processing firm must pay all the related taxes plus interest payments.

[11]The difference in tax policies for the processing and non-processing firms can potentially affect our TFP measures. We use tax included values of intermediate inputs and final output in our TFP estimation.

1.3.2 Summary Statisics

We start by showing the importance of processing exports in total Chinese exports. From Table 1.2 we see that over the sample period, approximately 20% of firms were processing exporters only and around 40% each were engaged in non-processing trade or in both types of activities, respectively. In terms of export value, pure processing exporters contribute about 30% of total exports. In Table 1.3 we report the distribution of processing intensity — defined as the share of processing exports in total exports — of firms doing both activities. The average processing intensity is higher in FIE firms (in terms of mean and median) compared to non-FIEs. Our data shows that processing trade is concentrated more in FIEs (Foreign Invested Enterprises), with over 80% of the total export value coming from processing trade. For the non-foreign firms, processing trade accounts for only about 30% of the total exports[12]. Figure 1.1 shows that processing intensity is higher in labor intensive sectors[13, 14]. The fact that processing exports are concentrated in FIEs and in labor intensive sectors suggest that the low productivity of exporters in these sectors found in previous studies is possibly being driven by low productivity of processing exporters; and in the next sub-section we will show that is indeed true. Figure 1.2 plots productivity by processing intensity. We find that exporters with processing intensity one (doing only processing trade) have significantly lower productivity than those with processing intensity zero (doing non-processing trade only). Exporters with low processing intensity are more productive than non-processing firms but productivity generally declines as firms' processing intensity increase.

[12]Table not reported.

[13]The correlation between processing intensity and sector capital labor ratio is -0.7.

[14]The capital labor ratio is defined as the median capital labor ratio in a two digit industry. Results are qualitatively similar if we use the aggregate capital labor ratio of the industry instead.

1.3.3 Econometric Analysis

In order to examine the performance of processing exporters versus non-processing exporters and non-exporters, we estimate the following equation:

$$y_{ijpt} = \alpha + \beta_1 PX_{ijpt} + \beta_2 NPX_{ijpt} + \beta_3 BX_{ijpt} + \epsilon_{ijpt} \tag{1.1}$$

Where y_{ijpt} is the dependent variable of interest (in logs) for firm i in industry j, province p and time t. $PX_{ijpt}$is a dummy which equals one if firm is a processing exporter (i.e. in any given year these firms only report processing transactions); NPX_{ijpt} is the dummy for non-processing exporters (i.e. in any given year these firms only report non-processing transactions); BX_{ijpt} is the dummy for exporters doing both processing and non-processing trade (i.e. in any year the firms report both processing and non-processing transactions); D stands for industry, province and year fixed effects and in some robustness specifications other controls like size and ownership. Our main variables of interest are productivity, including total factor productivity (TFP) measures and labor productivity measures such as value added per worker. We will show most of our results using TFP (Olley-Pakes) measure[15, 16], as it takes into account both the role of capital and the simultaneity of productivity shocks and input selection (issues ignored by value added per worker measure. Equation 1.1 is our baseline regression, it allows us to know if lower productivity of one or all types of exporters is important for explaining the documented unexceptional exporter performance in China.

We carry out regression 1.1 using value added per worker and TFP as our productivity measures. The results are reported in Table 1.4. We find that in terms of all productivity measures processing exporters are less productive than non-exporters; the coefficient of processing dummy being negative and significant. The results in-

[15]Details of construction of TFP using Olley-Pakes method is provided in A.2.

[16]Results are similar using other measures of productivity and briefly discussed in the Robustness section.

dicate that processing exporters are 4% to 30% less productive than non-exporters. Consistent with Melitz (2003) model, non-processing exporters and exporters doing both processing and non-processing trade are more productive than non-exporters. This table makes it clear that only the processing exporters demonstrate counter-Melitz productivity pattern. We also find that productivity decreases with processing intensity, indicating that less productive firms engage in processing trade more intensively[17].

We next investigate productivity of the different exporters by ownership: namely FIE and non-FIE firms, since previous literature has demonstrated low productivity of exporters in foreign owned firms[18]. Table 1.5 shows that irrespective of ownership type, processing exporters are the least productive of all exporters. Moreover, among FIEs it is only processing exporters that are less productive than non-exporters. Other types of exporters: those doing both processing and non-processing exports and those doing only non-processing exports have the usual superior performance of exporters – these firms are more productive than non-exporters. Thus the finding that exporters are less productive than non-exporters in foreign owned firms is being driven by inferior productivity of processing exporters.

We now check how much the anomalous behavior of exporters in the labor intensive sectors documented by Lu (2010) is influenced by the low productivity of processing exporters. We run the baseline regressions by capital intensity of the sector (low, medium or high capital intensity). Following Lu (2010) we define the capital intensity of a sector at the 2 digit industry level as the median capital-labor ratio in the sector.

In Table 1.6a we look at labor productivity (in terms of value added per worker)

[17]Table not provided in this paper but available upon request.

[18]We use two methods to identify a firm's ownership type. In the first method, we use the self-reported registration type of the firm, and in the second we calculate a firm's share of stocks owned by foreign partners. Following the definition from the National Bureau of Statistics, we define FIE to be a firm with over 25% foreign-owned stocks. The two methods yield qualitatively the same results, so we only report results using the first method.

of different types of exporters across capital intensity of the sectors and find that all exporters are less productive in the labor and medium intensity sector. However processing exporters are the least productive irrespective of the capital intensity of the sector; the co-efficient always being negative and significant. In Table A.2b in the appendix we show that the pattern for value added changes considerably once we control for firm size. Exporters in general become more productive than non-exporters in all sectors. Processing exporters, however, still remain the least productive, though the other two types of exporters become more productive than non-exporters, once we control for firm size[19]. From the discussion it is obvious that the poor labor productivity found in Lu (2010) is in part being driven by low labor productivity of processing exporters. We note that value-added per worker does not adjust for the role of capital but is positively correlated to the level of capital, hence labor productivity is mechanically higher in sectors and firms that use capital more intensively[20, 21]. To take into account the role of capital, we repeat the same exercise using TFP and report the results in Table 1.6b. We find positive and statistically significant coefficient for all exporters except processing traders, indicating that the former are always more productive (in terms of TFP) than non-exporters irrespective of industry capital intensity. We still find that the behavior of processing exporters is starkly different. They have lower TFP compared to the other exporters regardless of sectors and are less productive than non-exporters except in capital intensive sectors. Table 1.7 shows that similar results hold for the subsample of FIE firms.

Another feature of Chinese exporters is that around 30% of them are pure exporters i.e. they export their entire output. Lu (2010) predicts that pure exporters

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[19]The results by different exporter types after controlling for size is not reported.

[20]The correlation between labor productivity and capital labor ratio in our data is 0.35, while the correlation between TFP(Olley-Pakes) and capital labor ratio is only 0.02.This means that TFP is much less correlated with capital labor ratio and is therefore a cleaner measure of productivity.

[21]Moreover in China labor share is only around 50%, hence we should use productivity measures that account for the different factors of production.

are less productive than non-exporters in labor intensive sectors. Lu et al. (2010) also predicts that pure exporters are less productive than non-exporters within FIEs. To check if pure exporters are less productive, we re-run our baseline regressions by introducing six types of regressors: for each type of processing status we divide the firms into whether it is a pure exporter (has export intensity one) or a regular exporter (has export intensity between zero and one). Table 1.8 shows that pure exporters doing processing trade are the least productive, whereas pure exporters doing non-processing trade are more productive than non-exporters, irrespective of ownership type. Table 1.9 shows even in labor intensive sectors pure exporters doing non-processing trade are not less productive than non-exporters. These results imply that only processing trade firms have counter Melitz properties.

1.3.4 Robustness

In this section we perform a number of checks on the baseline specification to test the robustness of our findings. First, to ensure that our results are not entirely driven by firm size we include control for firm size (in terms of employment) and ownership in our regression analysis. The results are reported in Table 1.10, column 1. In column 2 we control for industry-province-year fixed effects to account for industry-province-year specific shocks. Pooling over the years might confound our results since China was undergoing changes in the post WTO accession period. So in column 3 we run the regression only for the last year in our sample — 2005, by which time China had met most of its WTO obligations. In column 4 we weight each firm by its industry value added share, so that large firms receive more weight in the regressions. Column 5 runs our baseline regressions after trimming the top and bottom 1% of the data to ensure that extreme values are not driving our results.

We have also re-run our regressions using alternative methods of constructing TFP such as the OLS technique, the system GMM approach by Blundell and Bond (1998), the Levinsohn and Petrin (2003) method of constructing TFP, and the physical productivity measure used by Hsieh and Klenow (2009)[22].

In all the above cases the results are qualitatively similar to our baseline results reported in Table 1.4 — in that processing exporters are the least productive.

1.4 Possible Explanations for Unexceptional Performance of Processing Exporters

The results in section 1.3.3 show that processing exporters are not exceptional performers. In this section we provide possible explanations for their poor performance. Since we are using revenue based productivity measures, the possible explanations can be broadly classified into two groups: (1) processing exporters are actually less productive; (2) measurement issues may make them appear less productive. These exporters may appear less productive if their pricing policy results in lower revenue or value added which gets translated into lower revenue based productivity measures.

We begin by discussing why processing exporters might be actually less productive than non-exporters. In the data we find that processing exporters are different in all dimensions. Table 1.11 shows that within industries, processing exporters are the least profitable; pay lowest wages per worker indicating that they hire relatively unskilled labor; are less capital intensive; and have the lowest per unit price of exports implying they export low quality products. Figure 1.1 shows that across industries processing exporters are concentrated more in labor intensive industries. The data thus indicates that processing trade is a different activity: that it uses relatively unskilled labor intensive technology to produce low quality product which also yields lower profits[23]. Coupled with this the fact that processing firms receive govt. tax

[22] Results using the alternative productivity measures are not reported but available upon request.

[23] These firms would be able to survive with lower productivity and by paying lower wages if there is product differentiation and firms make efficient use of their resources. The fact that the processing

benefits imply that processing has lower fixed cost. Hence only low productive firms become pure processing exporters[24]. Most productive firms would do both processing and non-processing trade. This hypothesis is supported by the productivity ranking of the different exporters in Table 1.4[25].

We now move on to discuss how processing exporters might appear to be less productive due to measurement issues. In our baseline results by ownership in Table 1.5, we find that the low productivity of processing firms is very pronounced in FIEs but not so much in non-foreign firms. Foreign owned processing firms through transfer pricing can potentially repatriate profits to a related party located in countries with lower tax rates. They can transfer profits by either selling their output to a related party at a low price or by purchasing inputs from a related party at a high price[26]. Since our productivity measures are revenue based, firms engaging in this form of transfer pricing can appear less productive than they actually are. It might be easier for foreign processing firms to set prices differently for intra-company transactions since there are often no natural benchmarks for the goods exported and imported by processing exporters. Unfortunately, the data does not provide any information to compare prices of similar goods sold to a related party and those sold to unaffiliated buyers to have direct evidence regarding the nature of transfer pricing. We rely on indirect information to check if transfer pricing is driving the low productivity of

exporters use relatively more unskilled labor and produce low quality goods can create downward bias our TFP measures since we treat labor and output as homogeneous when constructing productivity and thus these firms appear less productive though they are using inputs efficiently.

[24]Yu (2011) also finds that low-productive firms self-select to engage in processing trade.

[25]The possibility that processing exporters are doing a different activity implies that we should not be using the same production function for processing and non-processing firms. In this paper we use TFP measures widely used in the literature to establish the fact that the anomalous results previously reported is being driven by processing exporters and not by a new method of estimating TFP. However, as an additional check we have carried out TFP estimation by assuming different production functions for processing and non-processing firms and have obtained qualitatively similar results (tables not reported).

[26]Other ways of repatriating profits could be in the form of royalty payment or license fees that can keep profits low in the host country.

foreign owned processing exporters.

As mentioned before, transfer pricing by foreign owned processing firms can explain why the low productivity for processing exporters is very prominent for FIE firms. Next we check if systematic relationship exists between profitability and the degree of differentiation of goods among the different types of exporter. Profit repatriation through transfer pricing should be more prominent in sectors that have more differentiated goods since finding a comparable product is relatively more difficult in such sectors. Thus, if processing exporters are repatriating profits through transfer pricing, the difference in profits should be higher in the differentiated goods sectors. Table 1.12 compares profitability of non-exporters and the different types of exporters by import elasticity of the sectors. We use Broda and Weinstein (2006) import elasticity measures and divide goods into 3 types: those with high, medium and low elasticity; the latter being the most differentiated sector. Table 13 provides evidence consistent with profit repatriation through transfer pricing by FIEs. For these firms the gap in profits between non-exporters and processing exporters is the biggest in the low elasticity sector. No similar pattern can be found in non-FIE profitability difference between processing exporters and non-exporters[27].

Table 1.11 column 4 shows that input per unit of sales are the lowest for processing firms. This is at odds with the transfer pricing hypothesis, since firms engaged in repatriating profits abroad would want to push up the price of inputs and push down the price of the final goods, thus on average having higher inputs per unit of sales. It is possible that these firms are repatriating profits by using other methods that depress the profits (like royalty payment and license fees). Though we cannot rule out the role of transfer pricing behind the low productivity of foreign

[27] A similar comparison of unit value of exports shows no systematic pattern between ownership and degree of differentiability of the sector. This is at odds with the transfer pricing hypothesis – we would expect prices for FIE processing exporters to be lower in the differentiated goods sector where opportunity of setting prices differently for intra-company transactions is the biggest (table not reported).

owned processing exporters based on these evidence, it does not appear to be the sole driving mechanism. We must keep in mind that the FIE non-exporters are most likely practicing horizontal FDI, and are likely to be more productive than the typical non-exporter in the Helpman, Melitz, Yeaple (2004) type model. Viewed in this light, the fact that processing exporters are less productive than non-exporters particularly for foreign owned firms is not very surprising.

Low market power of processing exporters is also consistent with why these firms may appear to be less productive than non-exporters. These firms receive contracts from foreign firms, and the foreign firm owns the patent or blue print of the products hence can squeeze the processing/assembly unit's mark up and make them behave as price takers, which can lead to their low value added and revenue. We use levels of export, firm size, markup and industry market share as different proxies for market power. Following Keller and Yeaple (2009), markup is proxied by revenue over revenue less profits, and market size is proxied by share of firm's sale in total industry sales[28]. Table 1.13 shows that the productivity difference between processing traders and other types of firms exist even after controlling market power. Based on this evidence it appears that the low productivity of processing firms are not driven by their low market power.

In summary we can say that though different mechanisms can explain our result, the hypothesis that processing trade is a different activity – these are unskilled intensive jobs, yielding low profits, involve lower fixed costs and produces low quality products – compared to non-processing trade is the one that receives considerable support from the data.

[28]The data shows that processing exporters are smaller in terms of sales, markup and market size, so are likely to have less market power and would be easier to bargain with (table not reported).

1.5 Conclusion

Processing trade, in which parts are sourced globally and assembled at one place to be shipped to the final destination, explains bulk of the trade for the exporting powerhouse — China. This paper, merging Chinese firm level data with the customs data, provides new stylized facts about performance of processing exporters. We show that processing exporters are fundamentally different from non-processing firms. The firm level trade literature usually finds exporters to be exceptional performers. However, some recent papers on China document exporters to be less productive than non-exporters, both among foreign affiliates and in labor intensive sectors. We show that these anomalies are driven by the existence of processing exporters who are the least productive among all types of firms. Removing processing exporters restores the traditional finding since ordinary exporters are more productive than non-exporters. Our results imply that it is essential to consider processing trade separately from ordinary exporting activity when analyzing exporter performance in countries that have large processing trade sectors.

We explain different mechanisms consistent with our result, and find the hypothesis that processing/assembly is a different activity compared to ordinary trade is the one that receives the most support from the data. Our data indicates that processing involves unskilled labor intensive jobs that yield low profits and produces low quality products. Moreover, since processing requires lower fixed costs (due to government policy), only the low productive firms select into this activity. Transfer pricing can also explain the unexceptional performance of foreign-owned processing trade firms — especially since the low productivity of processing firms is very pronounced for FIE but not for non-FIE. The data provides mixed evidence about transfer pricing driving the low measured productivity of foreign owned processing firms.

Our findings have important policy implications. First, the re-allocation predictions in the presence of processing exporters are just opposite to that in the Melitz

(2003) model, in which a move towards exporting increases average productivity of the sector since exporters are more productive than non-exporters. A processing trade driven export surge, contrary to this belief, would reduce the average productivity since processing firms are the less productive ones. It thus becomes imperative to look into the costs and benefits of export processing. Exporting is often encouraged by countries on the ground that exporters are more productive and grow faster, so that they can act as an engine of growth. Given our findings, it also makes sense to evaluate learning from processing trade. This will have important policy implications for countries conducting processing trade or planning to do so. We plan to study this in the future.

Table 1.1: Comparing merged and unmerged exporters in the firm level data

	Merged exporters	Unmerged exporters
Log Employment	5.37	5.27
	(1.13)	(1.17)
Log Sales	10.6	10.33
	(1.30)	(1.31)
Value Added per Worker	87.32	71.58
	(203.10)	(147.69)
TFP (Olley Pakes)	4.22	4.12
	(1.15)	(1.12)
N	52955	137357

Note: The above table reports mean of the variables with standard deviation in the parentheses for merged and unmerged exporters.

Table 1.2: Share of number of firms and export value by processing status (year average)

Firm type	Number of firms	Export value
Non-processing	0.41	0.19
Processing	0.20	0.28
Both	0.39	0.53

Note: Authors' calculation using the merged data

Table 1.3: Processing intensity distribution of exporters doing both processing and non-processing trade

	All Firms	FIE	Non-FIE
Mean	0.60	0.64	0.42
sd	(0.36)	(0.35)	(0.34)
10th Percentile	0.06	0.08	0.02
25th Percentile	0.25	0.33	0.09
50th Percentile	0.68	0.77	0.34
75th Percentile	0.96	0.97	0.73
90th Percentile	0.99	0.99	0.99

Note: Authors' calculation using the merged data

Table 1.4: Productivity comparison by processing status

	Dependant variables	
	Value Added per worker	TFP(Olley-Pakes)
non-processing	0.024*	0.186*
	(0.009)	(0.009)
processing	-0.288*	-0.036†
	(0.019)	(0.017)
both	0.052*	0.240*
	(0.012)	(0.011)
N	427847	446018
R-squared	0.151	0.338

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters. All regressions include 4 digit industry, province and year fixed effects as additional control. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

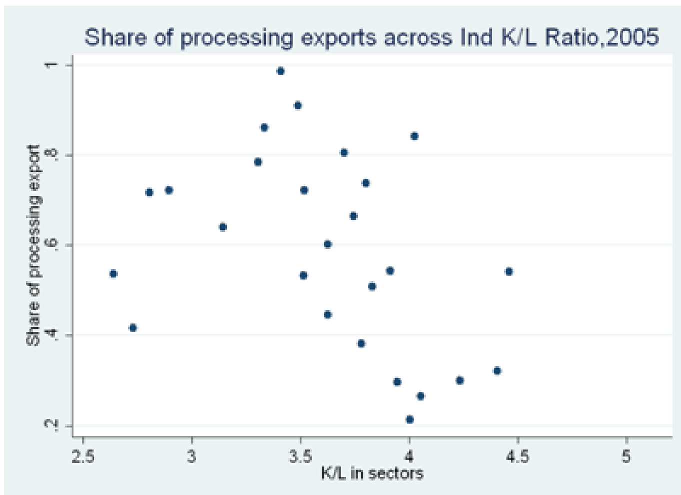
Table 1.5: Productivity of exporters by ownership

Dependant variable is TFP (Olley-Pakes)

	Foreign Owned	non-Foreign Owned
non-processing	0.090*	0.178*
	(0.014)	0.011)
processing	-0.085*	0.025
	(0.019)	(0.060)
both	0.116*	0.355*
	(0.014)	(0.023)
N	74763	371255
R-squared	0.331	0.343

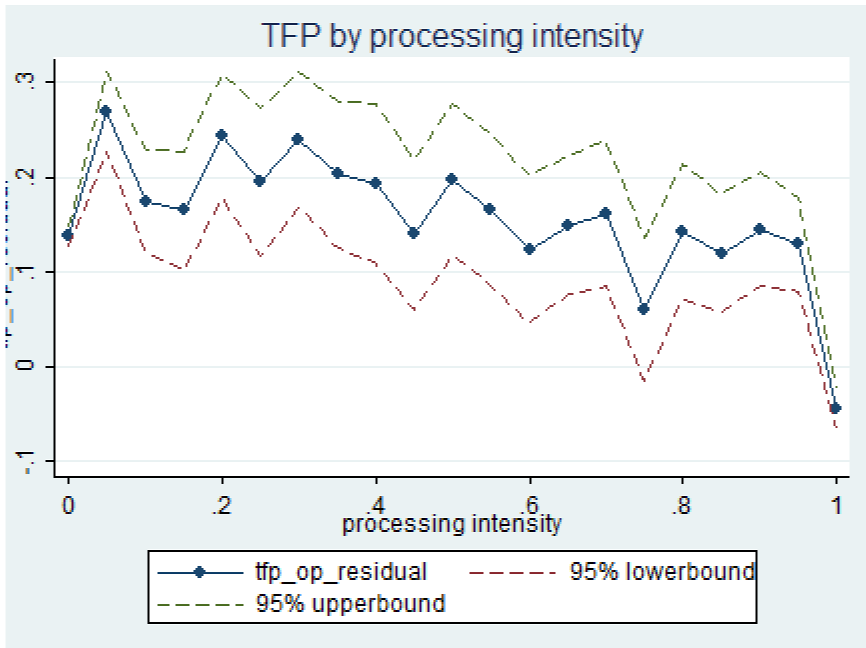
Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters, by subsamples based on ownership (FIE stands for Foreign Invested Enterprise). All regressions include 4 digit industry, province and year fixed effects as additional control. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Figure 1.1: Share of processing exports across capital intensity of sectors



Note: Authors' calculation using the merged firm-level and customs data.

Figure 1.2: TFP vs. processing intensity



Note: Productivity is TFP (Olley-Pakes) after removing industry-province-year fixed effects.

Table 1.6: Productivity comparison by processing status and capital intensity of the sector

(a) Dependent variable is value added per worker

	Labor intensive	Medium intensity	Capital intensive
non-processing	-0.104*	-0.035*	0.048†
	(0.013)	(0.014)	(0.023)
processing	-0.503*	-0.478*	-0.163†
	(0.026)	(0.030)	(0.076)
both	-0.187*	-0.064*	0.122*
	(0.017)	(0.020)	(0.040)
Observations	110939	189699	127209
R-squared	0.141	0.134	0.155

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters, by capital intensity of the sector. All regressions include 4 digit industry, province and year fixed effects. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

(b) Dependent variable is TFP (Olley-Pakes)

	Labor intensive	Medium intensity	Capital intensive
non-processing	0.10*	0.155*	0.241*
	(0.013)	(0.013)	(0.022)
processing	-0.206*	-0.099*	0.121††
	(0.023)	(0.026)	(0.066)
both	0.083*	0.197*	0.351*
	(0.016)	(0.018)	(0.035)
Observations	116119	197065	132834
R-squared	0.256	0.372	0.294

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters, by capital intensity of the sector. All regressions include 4 digit industry, province and year fixed effects. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Table 1.7: Productivity comparison by processing status and sectoral capital intensity (FIE only)

Dependant variable is TFP (Olley Pakes)

	Labor intensive	Medium intensity	Capital intensive
non-processing	0.062*	0.066*	0.192*
	(0.020)	(0.022)	(0.037)
processing	-0.139*	-0.076*	0.088
	(0.026)	(0.028)	(0.072)
both	0.059*	0.124*	0.270*
	(0.019)	(0.021)	(0.042)
Observations	26559	31305	16899
R-squared	0.293	0.359	0.297

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters, by capital intensity of the sector. Only foreign owned firms are included. All regressions include 4 digit industry, province and year fixed effects. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Table 1.8: Productivity of exporters depending on export intensity and processing status

Dependant variable is TFP (Olley-Pakes)			
	All Firms	Foreign Owned	non-Foreign Owned
Reg Ex+Non-Processing	0.191*	0.080*	0.191*
	(0.009)	(0.015)	(0.012)
Reg Ex+Processing	0.054*	-0.015	0.078
	(0.021)	(0.023)	(0.068)
Reg Ex+Both	0.278*	0.142*	0.380*
	(0.012)	(0.015)	(0.025)
Pure Ex+ Non-processing	0.162*	0.096*	0.134*
	(0.020)	(0.030)	(0.027)
Pure Ex+Processing	-0.262*	-0.297*	-0.189
	(0.024)	(0.026)	(0.150)
Pure Ex+Both	0.020	-0.067*	0.161†
	(0.024)	(0.026)	(0.074)
N	441765	71592	370173
R-squared	0.338	0.333	0.343

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade for regular and pure exporters separately, omitted group are non-exporters. All regressions include 4 digit industry, province and year fixed effects. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Table 1.9: Productivity of exporters depending on export intensity, processing status and capital intensity of sector

Dependant variable is TFP (Olley-Pakes)

	Labor intensive	Medium intensity	Capital intensive
Reg Ex+Non-Processing	0.098*	0.157*	0.256*
	(0.014)	(0.014)	(0.023)
Reg Ex+Processing	-0.157*	-0.016	0.245*
	(0.029)	(0.031)	(0.075)
Reg Ex+Both	0.109*	0.234*	0.395*
	(0.019)	(0.019)	(0.037)
Pure Ex+ Non-processing	0.109*	0.155*	0.034
	(0.025)	(0.036)	(0.090)
Pure Ex+Processing	-0.357*	-0.351*	-0.287*
	(0.032)	(0.040)	(0.100)
Pure Ex+Both	-0.049††	-0.119*	-0.054
	(0.029)	(0.048)	(0.094)
N	113577	195762	132426
R-squared	0.255	0.372	0.295

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade for regular and pure exporters separately, omitted group are non-exporters. The regressions are run separately for different capital intensity levels of the sectors. All regressions include 4 digit industry, province and year fixed effects. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Table 1.10: Robustness checks

Dependant variable is TFP (Olley-Pakes)	Size and ownership	Indst-province-year FE	Year 2005	Weighted regressions	Drop outliers
non-processing	0.124*	0.125*	0.108*	0.075*	0.117*
	(0.009)	(0.009)	(0.012)	(0.028)	(0.008)
processing	-0.168*	-0.164*	-0.256*	-0.058	-0.175*
	(0.017)	(0.018)	(0.024)	(0.051)	(0.015)
both	0.124*	0.125*	0.103*	0.121*	0.116*
	(0.012)	(0.012)	(0.016)	(0.032)	(0.011)
Observations	446018	446018	131118	426823	437098
R-squared	0.343	0.422	0.346	0.490	0.343

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters. Regressions in column 1, 4 and 5 include 4 digit industry, province and year fixed effects. Column 2 uses industry-province-year fixed effects. Column 3 runs regressions only for year 2005. Column 4 uses industry value added share as weights. Column 5 drops the top and bottom 1% of observations. All regressions include size and ownership (SOE and FIE) as additional controls. Robust standard errors in parentheses clustered at the firm level.* p<0.01, † p<0.05, ††p<0.1.

Table 1.11: Processing trade is a different activity

Dependant variable is TFP (Olley-Pakes)	Profit per worker	Wage per worker	Capital intensity	Input over sales	Export price
non-processing	0.025	0.094*	0.024†	0.010*	
	(0.018)	(0.005)	(0.012)	(0.002)	
processing	-0.486*	-0.030*	0.023	-0.038*	-0.140*
	(0.034)	(0.010)	(0.021)	(0.006)	(0.041)
both	0.086*	0.144*	0.221*	-0.007†	0.321*
	(0.024)	(0.007)	(0.015)	(0.003)	(0.028)
Observations	341204	427599	428189	447963	52883
R-squared	0.144	0.263	0.187	0.033	0.412

Note: The above table reports regressions of the dependent variable on non-processing, processing, and both dummies, omitted group is non-exporter (except the last column where the omitted group is non-processing exporters). All regressions include industry, province and year fixed effects, size and ownership of firm (SOE or FIE) as additional controls. Robust standard errors in parentheses clustered at the firm level.* p<0.01, † p<0.05, ††p<0.1.

Table 1.12: Evidence of transfer pricing using profits per worker

Dependant variable is TFP (Olley Pakes)	High	Med	Low	High	Med	Low
		FIE			non-FIE	
non-processing	0.061	0.017	-0.077	0.065††	0.128*	0.012
	(0.044)	(0.046)	(0.054)	(0.036)	(0.036)	(0.043)
processing	-0.246*	-0.264*	-0.393*	-0.278	0.325	0.423
	(0.052)	(0.073)	(0.075)	(0.180)	(0.230)	(0.290)
both	0.043	0.245*	0.082	0.293*	0.469*	0.284*
	(0.040)	(0.048)	(0.052)	(0.070)	(0.083)	(0.092)
Observations	22481	19408	12365	109412	113104	63452
R-squared	0.239	0.139	0.257	0.145	0.111	0.130

Note: The above table reports regressions of the dependent variable on dummies of non-processing exporters, processing exporters and exporters doing both types of trade, omitted group are non-exporters, by capital intensity of the sector. Only foreign owned firms are included. All regressions include 4 digit industry, province and year fixed effects. Robust standard errors in parentheses clustered at the firm level.* p<0.01, † p<0.05, ††p<0.1.

Table 1.13: Productivity comparison after controlling for market power

Dependant variable is TFP (Olley Pakes)

	Control for export	Control for markup	Control for market size
non-processing	0.309*	0.127*	0.006
	(0.019)	(0.008)	(0.006)
processing		-0.144*	-0.080*
		(0.017)	(0.011)
both	0.185*	0.132*	-0.023*
	(0.017)	(0.011)	(0.008)
N	43511	445280	445463
R-squared	0.475	0.373	0.578

Note: The above table reports regressions of the dependent variable on non-processing exporter, processing exporter, and exporter doing both, omitted group is non-exporter (except first column where processing firm is the omitted group). All regressions include industry, province and year fixed effects, size and ownership of firm (SOE and FIE) as additional controls. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Chapter 2

Imports, Offshoring and Wages: Rent Sharing or Composition?[1]

2.1 Introduction

One of the pertinent questions regarding globalization is: how does globalization affect wages? In this paper we address a particular aspect of that question: how does offshoring[2] affect firm level average wage? Offshoring firms are found to pay higher average wages than purely domestic firms (Bernard et al. 2007). Guided by existing theory, we provide empirical analyses of different possible channels through which offshoring can cause firm average wage differentials. Offshoring may push up firm level average wage in different ways: first, if firms offshore low-skilled low-wage tasks that automatically increases the average wage of the remaining jobs. We call this the skill composition effect. Second, offshoring can be viewed as new technology that firms adopt to reduce costs and increase revenue and profits. In a labor market

[1] **This chapter is written jointly with Henrik Bursland Fosse from Copenhagen Business School.**

[2] Offshoring here refers to a fragmentation of the production process due to relocation of jobs from the home country to the foreign country. Following Grossman and Helpman (2002) this includes intra-firm trade by MNE (vertical FDI) and arms length trade by MNE and non MNE firms.

environment featuring search, screening and bargaining frictions, offshoring firms and their workers bargain over firm specific rents — offshoring induced rents can increase wages of all existing workers and thus increase average wages in these offshoring firms. We call this the rent sharing effect.

We explain how much each effect contributes towards higher average wages in offshoring firms. Papers in the offshoring literature look at one channel at a time but not both. It is possible that both effects exist in the data and looking at one channel by ignoring the other may confound the results. In the past few years offshoring has become a major trading activity. The impact of offshoring on parent country labor outcomes stirs public controversy. We carefully investigate Danish worker-firm data to disentangle the effects of the two suggested mechanisms on firm average wages. It is important to distinguish the two effects from one another as policy makers would draw diametrically opposite conclusions from either effect. While we document the presence of the skill composition effect, underlining that certain jobs in Danish firms do move out of the country, we also document that Danish firms benefit from increased profitability and share this increased profitability with workers, i.e. through rent sharing. Thus the presence of the one channel, skill composition, highlights what developed nations worry about, but there is also the rent sharing channel that tells a positive story about offshoring, and for some firms we find that the latter channel completely accounts for the differential wage gains from offshoring.

Identifying the causal relationship between offshoring and higher firm level average wage is difficult. First, firms endogenously select into offshoring: firms that offshore are, on average, larger, more productive, and tend to pay higher wages than smaller firms that are less productive and less likely to offshore. Second, higher skilled workers may select into offshoring firms because these firms are bigger and pay higher wages. Thus, separating the causal story from the selection story is important, i.e. to say whether the higher average wage paid in offshoring firms stems from offshoring per se or from higher productivity that simultaneously leads to more offshoring, higher output, and wages.

We use Danish worker-firm data that tracks the universe of Danish workers across the universe of Danish firms. This amazingly rich dataset provides detailed information on individuals' wage histories from which we are able to construct measures of skill composition effect and rent sharing effect at the firm level. Following Abowd, Kramarz, and Margolis (1999) (henceforth AKM), and Frias, Kaplan, and Verhoogen (2009), we decompose the firm level average wage in each year into an average person component, reflecting the skill composition of the workforce, and a firm component which we interpret as the measure of time-varying firm specific rent sharing.

We use events in China to identify the causal effect of a change in the incentive to offshoring on firm level average wages. We argue that two possibly related events occurred: First, China's accession to the World Trade Organization (WTO) in December 2001 created a surge in foreign firms operating in China as well as new Chinese exporters. Upon accession, China made enormous changes to meet its WTO obligations including among other things restructuring industries, publishing previously internal laws and regulations, establishing formal procedures to adjudicate disputes, leveling the playing field for foreign firms, and giving all firms right to trade. These changes were phased in gradually over a transition period, usually within three years after accession, directly influencing firms' incentive to offshore to China. Second, there was a boom in Chinese world exports around 2003 driven by the structural changes undertaken by the Chinese government around that time. This led Chinese exports to more than double from 400 billion US dollars in 2002 to 900 billion in 2005. The surge in Chinese exports acted as an additional indirect incentive for firms in Denmark to source from China in order to maintain competitiveness with firms who would have cost advantage by sourcing cheaper Chinese resources. Thus, China's joining the WTO can be viewed as a shock to the trading environment in China and the observed Chinese export boom as a cost/technology shock, to which we expect Danish firms to respond. In fact, we do see a jump in the Danish share of imports from China in 2003, indicating that Danish firms were affected by the shock.

The first step of our analyses is to ensure that within industries, firms offshoring to China were affected differently compared to firms who were not offshoring to China[3] in the 2002-2005 period. Next we check that the differential change was greater during the shock period, 2002 -2005, compared to an earlier period, 1999 -2001. This procedure ensures that we are identifying trend differentials between two completely different periods and thus not trend differentials, a priori, between two types of firms – the treatment and the control group.

We find that, between 2002-2005 average wage increased around 1.5 percent more in firms offshoring to China compared to the control group. The skill composition effect accounted for a quarter of the differential increase while the rest was explained by rent sharing. Our results are robust to controlling for underlying trend differences i.e. comparing the wage gain in 2002-2005 with an earlier period, 1999-2001. We get heterogeneous results once we split firms up by their offshoring status in China: the differential wage increase between the two periods was the largest for the new offshorers i.e. firms offshoring to China in 2002[4] but not in 1999[5] and was explained by rent sharing only. The continuing offshorers i.e. firms that offshored to China in both 1999 and 2002 experienced differential wage increase between the two periods mostly through the skill composition effect. Firms offshoring to China in 1999 but not in 2002 showed no differential wage change in this period. These heterogeneous patterns are not discernible when we use common proxies for measures of skill composition and rent sharing[6] available in the typical firm level datasets. The difference in results when using measures of composition and rent sharing effects

[3]In particular the control group used in the results presented in this paper includes firms offshoring to other low middle-income countries but not China in 2002 and non-offshoring firms.

[4]2002 is the beginning of the defined shock period.

[5]1999 is the beginning of the defined pre-shock period.

[6]Such as ratio of educated to uneducated workers and sales per employee.

from the firm level data to those constructed from the worker-firm data shows that we should draw results from the typical firm level data (commonly used in the offshoring literature) with more caution.

In addition to papers that use linked worker-firm and firm level data our work is related to a number of papers using industry level data. Feenstra and Hanson (1996, 1997) show that offshoring affects firm level average wage by affecting the skill composition of the domestic workforce. Becker, Ekholm and Muendler (2009) find evidence that offshoring is associated with a shift towards more non-routine and interactive tasks as well as a shift towards more educated workers (skill composition effect) in German MNEs. In these models the labor market is assumed to be perfectly competitive and cannot account for possible rent sharing effects. Allowing for imperftectly competitive labor market, Bagger, Christensen and Mortensen (2010) find evidence of rent sharing in the Danish labor market, but their paper does not address the offshoring issue. Sethupathy's (2008) bargaining model assumes homogeneous labor and shows that offshoring increases productivity and profitability of offshoring firms compared to non-offshoring firms. The differential increases lead to higher domestic wages at offshoring firms through a positive rent sharing mechanism. Using US MNE firm level data he provides evidence that higher average wages at offshoring firms is consistent with a rent sharing mechanism. However, his outcome is also consistent with the skill composition effect and his results do indicate that the skill composition effect is present. Kramarz (2008) also uses a bargaining model to show that offshoring can affect wages directly by altering firms' threat point and thus changing the overall quasi-rent shared between firms and workers. His model shows that level of union strength matters, with firms facing stronger unions offshore more, decreasing the size of the quasi-rent to discipline workers. Using French worker-firm data he shows that firms facing stronger unions increased offshoring more with an associated decline in employment and rents. His results indicate that offshoring might have a dampening effect on wages through the rent sharing mechanism. His paper also assumes homogeneous labor and is silent about the skill composition channel. Hummels et al. (2010) analyze relationship between offshoring and workers' wages and employment opportunities also using Danish employer-employee data. They find that exogenous import shocks increases wages of skilled labors and decrease wages of unskilled workers, whereas shocks to exporting increases wages of both types of workers. They also look at the relationship between displaced workers and offshoring and find that workers displaced by offshoring experience more persistent wage losses compared to those displaced for other reasons, and the effect is more pronounced for low-skilled workers. Our results complement their findings on wages and shocks to offshoring; we show that offshoring affects average wages through both skill composition and rent sharing effects. A paper close to ours in terms of econometric methodology is Frias, Kaplan, Verhoogen (2009) (henceforth FKV), we use their method for constructing measures of firm level skill composition and rent sharing effect from worker's wage level data.

The paper proceeds as follows. In section 2 we discuss the theoretical motivation behind our work. Section 3 describes the dataset. Section 4 discusses the econometric methodology and identification strategy. In section 5.1 we use firm level measures similar to what has been used in the offshoring literature in the absence of worker-firm data. In section 5.2 we make full use of the worker-firm data to decompose firm level average wage into a skill component and a rent sharing component and analyze how a shock in the incentive to offshoring affects average wages through these channels. Section 6 does robustness checks and section 7 concludes.

2.2 Theoretical Motivation

In this section we briefly sketch the theoretical motivation behind our work. Suppose there are heterogeneous firms who differ in terms of productivity; heterogeneous workers who vary at the skill level; imperfections in the labor market with presence of search costs, screening and wage bargaining leading to rent sharing between firms and workers. As a result, wage of each worker type depends on the share of firm-specific rents. We do not assume any particular form of rent sharing —i.e. the form can be profit sharing, revenue sharing or both[7]. Both high-skilled and low skilled tasks are required for production of a good. Either type of task can be offshored which involves a marginal cost and a common fixed cost. Heterogeneous firms and fixed cost of offshoring imply that only the most productive firms can endogenously select into offshoring. The less productive firms must source from the home market.

A new offshoring opportunity can be viewed as new technology involving a fixed cost and a lower marginal cost compared to sourcing from the home market. Following a fall in the cost of offshoring, more firms will be able to take advantage of this technology but some firms will still not be productive enough to overcome the fixed cost. The new offshoring opportunity will imply displacement of jobs in firms that offshore. Thus, a fall in the cost of offshoring changes the skill composition in the offshoring firms compared to the non-offshoring firms. If relatively low skilled, low wage jobs are sent abroad then onshore skill composition increases. Because skilled labor earns higher wage, offshoring increases the average onshore wage through a pure composition effect. This effect was first suggested in Feenstra and Hanson (1996). We call this the skill composition effect on firm level average wage[8].

We expect that firms become more cost efficient by taking advantage of new offshoring opportunities. This effect leads to a reallocation of production and profits towards the offshoring firms. If rent sharing exists between firms and workers then the wage of the average worker increases in offshoring firms and falls in the disadvantaged, non-offshoring firms. We call the second effect the rent sharing effect. Thus both the

[7]Some commonly used, empirical proxies of firm specific rents are: sales per employee (revenue) or profits per employee (profit sharing).

[8]This effect can work in either ways: if high-skill jobs are offshored the onshore skill composition falls causing the average onshore wage to fall. Recent empirical evidence suggests that offshorability does not solely depend on the skill level of the task but rather on the degree of routineness and interactiveness of the task. So offshoring can indeed decrease the onshore skill composition.

skill composition and the rent sharing effects could be responsible for higher domestic wages at offshoring firms compared to non-offshoring firms. Our empirical approach in sections 4.2 and 5.2 investigates how much each channel contributes towards higher average wage in offshoring firms. While the skill composition effect provides evidence for the type of jobs offshored within firms, the rent sharing effect is evidence for the firms' profitability and their survival in the market. It is important to distinguish between the two effects, since these two effects will have different policy implications.

For a simple illustration of the two effects at work, let us consider the very simple case of two types of labor: low skilled (L) and high-skilled (H) labor. Onshore firm level average wage $\bar{w}$ can be expressed as:

$$\bar{w} = \sum_{f=\{L,H\}} s_f w_f$$

where s_f is the onshore share of labor of type-f and w_f is onshore wage of worker of type-f worker, f={L,H}. We can decompose the discrete change in firm level average wage that we observe in the data as:

$$\Delta \bar{w}_f = \sum_{f=\{L,H\}} \Delta s_f w_f + \sum_{f=\{L,H\}} s_f \Delta w_f \tag{2.1}$$

The first term on the right hand side is the change in firm level average wage due to a change in skill composition and the second term is the change in average wage brought about through a change in the wage of each type of worker, e.g. due to a rent sharing mechanism.

Many settings can lead to simultaneous increase of revenues and profits with wages. We suggest a causal explanation by using a shock in the incentive to offshore and splitting up the effect on firm average wages into two channels: (1) skill composition change that affects firm average wage and (2) changes in profits that are shared through rent bargaining leading to all wages increasing at the firm and thus also firm average wages.

Other possible explanations include that more productive firms induce higher learning and thus higher wages. Offshoring firms may transfer knowledge across the border and increase worker productivity locally, making their workers — otherwise identical to workers in lower productivity firms — more valuable and thus pay them higher wages (Malchow-Møller, Markusen and Schjerning, 2007). We believe that this possible explanation is not a likely concern in our setting: it is not obvious that sourcing from China generates these types of spillover gains for workers, and certainly not in the first years following the broad opening up of China.

One might also think of compensating differentials: to take a job or stay in a job in a sector or a firm where workers —due to offshoring — face the risk of being separated from their jobs or reallocated to less attractive job positions, the firm may have to offer workers a compensating differential. We consider this reasoning amounting essentially to a type of rent sharing: the management team at the firm still needs stable onshore labor, and workers use their bargaining power when they see profitability at the firm increases.

What we track in our estimates are changes to the level of firm fixed effects on firm average wages during a period. We do not track the composition of the level of worker-firm time-varying fixed effects. Thus, we stick to the concept of rent sharing when talking about estimated changes to time varying firm fixed effects. Note that the conclusions one draws form the two channels are diametrically opposite. The skill composition channel suggests what kind of jobs Danish firms offshore to China. This channel thus underlines an imminent concern for policy makers — how to compensate the workforce separated from their jobs as a result of offshoring. The rent sharing effect however underlines that there are positive sides to offshoring because it increases profitability of the firm and the firm shares part of the profits with its workers, thus contributing to improved welfare.

2.3 Data

Our main data source for this paper is the very rich, Danish, annual, matched, worker-firm panel from Statistics Denmark. The data currently spans from 1996-2008 and includes data from three linked databases, FIDA (1996-2008), IDA (1980-2008), and firm level External Trade Statistics (1990-2008). For our baseline results we use data on manufacturing firms only spanning from 1999-2005. All data are restricted and provided by Statistics Denmark.

FIDA is the Firm Integrated Database for Labor Market Research. It contains the (almost) full population of firms registered in Denmark. It provides accurate firm level data, including general, external accounting statistics, number of employees, and a record of individuals employed in the firms. Via a person key, FIDA can be linked to the Integrated Database for Labor Market Research (IDA), containing extensive information on socio-economic characteristics of the population of Danish residents. IDA variables include among others hourly wage, status on connection to labor market, age, sex, education, experience, tenure, and occupation. Education can broadly be classified in three categories: high-skilled, requiring tertiary education; medium skilled, requiring vocational education defined as consumption of secondary education; and low skilled, defined as persons with short cycle education (typically 1-2 years) or high school education.

Via a firm key, we also link the worker-firm panel to firm level External Trade Statistics (1990-2008). This adds country-product level[9] bilateral external trade data to our dataset. Each trade flow contains information on the value of trade in DKK (f.o.b prices for exports and c.i.f prices for imports), the weight, and the volume. This dataset allows us to investigate the effect of a change in the incentive to offshore on firm level average wage.

[9]Product classification is the European Combined Nomenclature (CN), 8-digits. We use at the maximum 6-digit level which is consistent with HS-6 classification.

Our main results are based on core manufacturing firms (NACE 15-36)[10]. We consider firms with 10 or more employees. We also carry out robustness checks where we use our entire sample of firms. Our measure of offshoring is a broad one that includes firms' imports of both intermediate and consumption goods. For example a positive productivity or cost shock in China might affect offshoring decision of Danish firms, hence their imports and wages. In line with our theoretical motivation, firms that are able to import consumption and intermediate goods are able to expand their available potential technologies with associated increase in profitability that get translated into higher firm level average wage through rent sharing. Imports by manufacturing firms will also affect the kind of tasks (low skill and high skill) performed in the domestic firm and thus affect firm level skill composition. In our empirical analysis, imports as a share of sales proxy for offshoring at the firm level, and we proxy offshoring firms as those sourcing from abroad. Skill composition and rent sharing measures are constructed from the data using a worker level wage regression equation and explained in detail in the estimation strategy section. Table 2.1 provides comparison of firm level characteristics for the year 2005. Consistent with firm level findings in other countries, Danish firms that offshore are bigger in terms of employment and sales; have higher skill ratio (in terms of educated and non-educated workers), profits per employee and hourly wage, both on average and for each type of employee. For example offshoring firms have on average 85% higher employment and 36% higher sales than non offshoring firms. This result holds for other years in the sample as well[11]. However, these results do not provide a causal mechanism from offshoring to higher wages, which we discuss in the following section.

[10]Manufacturing firms best suit the underlying theoretical motivation and has often been used in empirical papers in the offshoring literature.

[11]The column to the far right of Table 2.1 presents results from simple mean difference regressions (i.e. statistical differences between means for offshoring firms and means for non-offshoring firms).

2.4 Estimation

We are interested in assessing how a change in the incentive to offshore affects firm level average wage through the skill composition effect and the rent sharing effect. In the first step we show how firm level average wage can be split into a rent sharing component and a skill component. Our estimation strategy of decomposing firm level average wage essentially relies on the FKV technique. In the second step we relate the change in average wage and the two components arising from an exogenous shock in the incentive to offshore to China. We begin by discussing our second step: the identification strategy. Then we move on to our estimation method.

2.4.1 Identification Strategy

In this section we argue why we choose 2002-2005 as the *shock period* for our difference-in-differences estimations. 1999-2001 will act as our *pre-shock perio*d. In the following discussion we thus refer to the years 1999, 2001, 2002, and 2005 as they mark the beginning and the end of the two periods considered. We base our segregation of firms into control and treatment groups based on the firms' status in the first year of the two periods considered (i.e. 1999 or 2002).

To test how a change in offshoring opportunity affects firm level average wage through composition and rent sharing effects, we use events in China as exogenous shocks in the incentive to offshore to China. The events represent business condition, cost and productivity shocks in China and are likely to affect many local decisions of Danish firms. Our analysis does not compare the clean case of increasing wage differentials between firms offshoring and firms not offshoring. Instead, the estimations are carried out as increasing wage differentials between firms taking advantage of a new favorable offshoring destination and firms that do not.

China joined the WTO in December 2001, which was a very important event for the Chinese economy. An export boom[12] occurred in China soon after China joined the WTO, driven by the different policies undertaken by the Chinese government. These two events mark China's coming to the forefront as an important member in the global economy. China's accession to the WTO implied comprehensive liberalization, some of which would come into effect immediately whereas others were to be phased in over a period of typically less than three years. Some of the key components of China's accession to the WTO involved:

(i) Gradual tariff reduction of agricultural and non-agricultural commodities. However the scope of tariff reduction was not massive, only 40% of about 10,000 products at HS8 level were eligible for tariff reductions over a period of five years with tariffs for the majority of the products being reduced by 2005.

(ii) Services commitments involving substantial market opening of a broad range of service sectors, including banking, insurance, telecommunications, and professional services.

(iii) Phasing out of NTM such as licenses, quota, tendering state trading, export subsidy and removal of all WTO inconsistent non-tariff measures (NTMs) by 2005 as well as elimination of China's trade related investment measures (TRIMS).

(iv) Allowing all firms (whether domestic or foreign) the right to directly import from and export within three years from accession — also providing the right to engage in distribution of all products in China within three years of accession (except certain extended restrictions on chemical fertilizers, crude oil, and refined petroleum).

(v) The provisions of systemic reforms involved broad reforms in the areas of transparency, notice and comment, uniform application of laws, and judicial review to help address barriers to foreign companies doing business in China.

(vi) China agreed to elimination of state-trading import monopolies for agricultural and industrial products and to the requirement that state-owned enterprises must make purchases and sales based solely on commercial considerations.

[12] See Figure 2.1.

Accession to the WTO signaled credibility to the world that China was open for more foreign investment and trade. Given the enormous changes that were to take place to facilitate both foreign investment in China and imports from China to the rest of the world, China's accession to the WTO appears to be a shock of considerable magnitude to the incentive to offshore to China since it created a more conducive trading and business environment. This is the direct impact of China's joining the WTO on the offshoring incentive of Danish firms.

The WTO membership for China helped in spearheading further economic reforms, opened up the Chinese market for more international trade and higher levels of foreign investment, and opened up the world economy for Chinese exports. This, along with the various structural changes and liberalization policies adopted by the Chinese government around that time, led to a surge in China's exports soon after it joined WTO. Figure 2.1 shows that growth of exports from China to the rest of the world (excluding Denmark) picked up in 2003 and 2004. China's emergence as a major exporter had an indirect impact on firms' incentive to offshore from China from a third party competition angle. If a firm does not source inputs from China, but its rival firms (either in the same or a different country) do so and reduce their costs and prices, then the firm has to follow suit or risk losing market share. Thus, as the rest of the world begins sourcing cheap inputs from China, we should expect firms in Denmark to behave similarly. One observation of interest is that though China joined the WTO in December 2001, we see exports increased the most from China to the rest of the world in 2003 and 2004. Two explanations are, first, that China had a transition phase to complete the liberalization, so the initial changes were not large enough to drive a large increase in exports immediately. Second, a small recession in the world economy in the post 9/11 crisis dampened the export growth from China in 2002. What is important in our context is that both these shocks, possibly related, and global in nature, are exogenous to a small open economy like Denmark and would not be affected by local firm behavior but would influence them.

From Figure 2.2 and Figure 2.3 we see that Danish firms, both manufacturing and non-manufacturing, reacted strongly to these episodes in China. Figure 2.2 shows the growth charts of Danish manufacturing imports from top non-EU15 partners and Eastern Europe. Imports from China (CN) by Danish manufacturing firms take off in 2003 while this is not true for imports from Eastern European countries. These import responses are consistent with the surge in Chinese world exports.

Figure 2.3 shows the number of firms (manufacturing and non-manufacturing) importing from China as share of total firms, from 1999 to 2005. This pattern also holds for the number of firms importing from China, for example in 2002 both the total number of firms and manufacturing firms sourcing from China increased sharply, by 37% and 30%, respectively, by far the biggest increase during 1999-2005. From 2001 to 2005 the number of firms importing from China increased over two times from about 3000 to 7000, the corresponding numbers for manufacturing shows an increase by two times approximately from a little less than 500 firms in 2001 to about a 1000 in 2005 (tables not reported). The above discussion indicates that Danish firms, both manufacturing and non-manufacturing, did respond to the shock of China's emergence as a leading exporter following its accession to the WTO.

Since the number of firms sourcing from China has increased dramatically over a few years, we want to know about the nature of the firms that were sourcing from China before we see a surge in share of imports from China in 2003. We divide firms into the following four types: i) firms offshoring to China both in 2002 and 1999, ii) firms offshoring to China in 2002 but not in 1999, iii) firms offshoring to China in 1999 but not in 2002, and iv) firms offshoring to low middle-income countries but not China in 2002 and 1999 and non-offshoring firms, for the year 2002. In Table 2.2, a comparison of firm characteristics based on the types listed above, show that the firms who were sourcing from China in 2002 but not in 1999 (new offshoring firms) are relatively smaller in terms of sales and employment compared to firms who were sourcing from China in both 1999 and 2002 (existing offshoring firms), as well as firms who were offshoring to China only in 1999 but not in 2002 (former offshoring firms). The omitted group consists of firms offshoring to low middle-income countries but not China and non offshoring firms in 2002 and 1999.

Unlike other papers in this literature, we do not restrict offshoring to be only intermediate goods imports for manufacturing firms; consumption goods imports are also considered as offshoring in this paper. In Table 2.3 and Table 2.4 we list consumption and intermediate commodities, respectively, based on the value imported in 2005 and 1999. Table 2.3a and Table 2.4a list top 10 commodities (based on their value of imports in 2005 in DKK) that are classified as consumption goods and intermediate goods respectively. For example Table 2.3a shows that boys jackets and trousers (HS6 products 620333 and 620343) are among the top products directly imported by Danish manufacturing firms from China in 2005. We consider this as offshoring: if the firms are making the garment designs in Denmark and producing the garments in China and importing them back to Denmark, where they are labeled and packed then it constitutes as offshoring in our context because fragmentation of the production process occurs. Relocating production to China implies lower production costs, and that is likely to induce skill composition and rent sharing effects. Moreover many of the food products that are listed as consumption goods could very well be intermediate inputs in food manufacturing firms. Thus the fact that the surge in imports from China to some extent is driven by consumption goods works well for the offshoring framework we have in mind. Table 2.5a indicates that most of the increase in Chinese imports between 2002 and 2005 was at the intensive margin; intensive margin being defined as commodities imported from China in 2002 as well as 1999 at the HS6 product category level.

Finally, Table 2.5b provides the decomposition by two broad firm categories those importing from China in 2002 and those not importing from China in 2002 but importing from China sometime between 2003 and 2005. We see that the former category contributes more towards the total change in imports from China between

2002-2005 period, mostly through the intensive margin; for the latter group, the entire change is by definition at the extensive margin.

2.4.2 Firm Level Average Wage Decomposition

We use the basic statistical framework of AKM for decomposing information on individual workers' wage into individual heterogeneity and firm heterogeneity. The linear worker-firm regression model of AKM with time-varying firm effect is:

$$w_{it} = \alpha_i + x_{it}\beta + \psi_{j(i,t)} + \epsilon_{it} \tag{2.2}$$

where i, j, and t are individuals, firms and time respectively; w_{it} is log wage; α_i is the time-invariant individual fixed effect. x_{it} is a vector of observable time-varying individual characteristics. So these components comprise the skill effect on individual wages. $\psi_{j(i,t)}$ is the time-varying firm effect. The function $j(i,t)$ indicates the firm in which worker i is employed in period t. We allow the firm effect $\psi_{j(i,t)}$ to vary over time to take into account changes in firm's wage policies in response to trade shocks. ϵ_{it} is the residual, with the identifying assumption that $E[\epsilon_{it}|i,t,x] = 0$ and is orthogonal to all other effects in the model.

Following FKV, we now decompose the firm average wage into an average rent sharing component and an average skill component. The way we do is by subtracting from the variables their mean across individuals at each point in time. Note from equation 2.2 that

$$\alpha_i = w_{it} - x_{it}\beta - \psi_{j(i,t)} - \epsilon_{it}$$

Recalling that $E(\epsilon_{it}) = 0$, we then define the mean deviation of α_i at time t as $\tilde{\alpha}_i$

$$\tilde{\alpha}_i \equiv \alpha_i - \bar{\alpha}_i = \alpha_i - E(w_{it} - x_{it}\beta - \psi_{j(i,t)} - \epsilon_{it})$$

The sample analogue of the expression above uses the estimated parameters $\hat{\alpha}_i$, $\hat{\beta}_i$, and $\hat{\psi}_{j(i,t)}$ of equation 2.2:

$$\hat{\tilde{\alpha}}_i = w_{it} - x_{it}\hat{\beta} - \hat{\psi}_{j(i,t)} - \bar{w}_t - \overline{x_t\hat{\beta}} - \overline{\hat{\psi}_t}$$

Define $\tilde{s}_{it} = s_{it} - \bar{s}_t = \tilde{\alpha}_{it} + x_{it}\beta - \overline{x_t\beta}$ as the mean deviated value of s_{it} and introducing, as above, the sample analogue we get:

$$\hat{\tilde{s}}_{it} = \hat{s}_{it} - \bar{\hat{s}}_t = \hat{\tilde{\alpha}}_{it} + x_{it}\beta - \overline{x_t\hat{\beta}}$$

Inserting the expression for $\hat{\tilde{\alpha}}_i$ and manipulating we get the individual mean deviated wage as:

$$w_{it} - \bar{w}_t = \hat{\tilde{s}}_{it} + \hat{\psi}_{j(i,t)} - \overline{\hat{\psi}_t} \tag{2.3}$$

Taking the average across individuals within each firm j, we arrive at the split of firm average wage into an average skill component and a rent sharing component, expressed in values as mean deviated by individual means at time t:

$$\underbrace{\frac{1}{N_{jt}}\Sigma_{i=1}^{N_{jt}}(w_{it} - \bar{w}_t)}_{\substack{\text{firm avg. wage} \\ \text{(deviated)}}} = \underbrace{(\hat{\psi}_{j(i,t)} - \bar{\hat{\psi}}_t)}_{\substack{\text{rent sharing} \\ \text{(deviated)}}} + \underbrace{\frac{1}{N_{jt}}\Sigma_{i=1}^{N_{jt}}(\hat{s}_{it} - \bar{s}_t)}_{\substack{\text{avg. skill comp.} \\ \text{(deviated)}}} \tag{2.4}$$

Denoting the mean deviated variables at the firm level in equation 2.4 as $\breve{y}_{jt} = \bar{y}_{jt} - \bar{y}_t$, we now have the variables $\breve{w}_{jt}$, $\breve{s}_{jt}$ and $\breve{\psi}_{jt}$. Analogous to the above equation , we can write:

$$\triangle\breve{w}_{jt} = \triangle\breve{s}_{jt} + \triangle\breve{\psi}_{jt}$$

Using these three variables as our dependent variables in difference-in-differences estimations allows us to break down the coefficient on the treatment dummy in the $\triangle\breve{w}_{jt}$ — regressions into the coefficients of the treatment dummies in the $\triangle\breve{s}_{jt}$ and $\triangle\breve{\psi}_{jt}$ — regressions, respectively. Thus, we track changes in firm average wages and contribute the reason to either skill-compositional changes, rent-sharing effects from increased profitability[13], or both. Once again we underline that results from this split leads to completely different policy conclusions: skill compositional changes underline

[13] One caveat with this rent sharing measure is that it is at the firm level. It might be possible that the increased profitability from offshoring is shared with some workers (for example: high ranked workers) and not all.

that Danish firms do offshore low-skill jobs, but rent sharing effects increase wage for workers at the Danish firms which adds a positive welfare story to offshoring that has direct positive impact on workers at the firm.

2.4.3 Estimation Equations

We test our theoretical motivation given by equation 2.1 in section 2.2, using two types of difference-in-differences (D-i-D) estimations and a set of outcome variables. Based on the identification strategy discussion earlier we define our shock period to be 2002-2005 and a pre-shock period to be 1999-2001. Our D-i-D equations are:

$$\triangle y_{kj} = \alpha + \beta d\_2002 + D_j + \epsilon_{kj} \tag{2.5}$$

$$\triangle y_{kj} = \alpha + \beta_1 d\_1999\_2002 + \beta_2 d\_0\_2002 + \beta_3 d\_1999\_0 + D_j + \epsilon_{kj} \tag{2.6}$$

$\triangle y_{kj}$ is the change in an outcome variable of interest for firm k in industry j (D_j captures industry fixed effects). We consider the difference over 2002-2005. In equation (6) d_2002 is a dummy variable for firms offshoring to China in 2002. Thus d_2002 is our treatment firms; control firms (omitted group) are firms who offshore to other low-middle income countries but not China as well as firms that do not source inputs from abroad in 2002[14, 15].

Equation 2.6 carries out difference-in-differences estimates by firm types, depending on when they were offshoring to China prior to 2003. As mentioned in the data section, the types that we consider are: d_1999_2002, firms sourcing from China in both 1999 and 2002; d_0_2002, firms offshoring to China in 2002 but not in 1999;

[14] To test for trend differences in a D-i-D-i-D.

[15] Results are similar using other treatment and control group. See the section on robustness.

d_1999_0, firms offshoring to China in 1999 but not in 2002. The omitted group is non-offshoring firms and firms not offshoring to China but other low middle income countries. The main outcome variables of interest are 1) firm level average wage, 2) skill composition, and 3) rent sharing. All results in the next section use Danish manufacturing firms only (NACE 15-36).

We carry out all estimations following two parallel tracks: One track utilizing only typical firm level information, and a second track making full use of the worker-firm matched data. Comparing these two approaches demonstrates the fruitfulness of having worker-firm matched data even though the scope is firm level analyses.

2.5 Results

2.5.1 Estimating Results from Firm Level Data

We begin by looking at firm level variables before decomposing firm level average wages into skill composition and rent sharing components from worker level regression. Typically, firm level datasets give skill ratio (skilled vs. unskilled), sales per employee (rent sharing). Apart from gauging the impact of the shock on various firm level outcomes, this exercise allows us to compare our results obtained from using more nuanced measures of skill composition and rent sharing effects by taking full advantage of linked worker-firm information with those that are commonly used in the literature and readily available in typical firm level datasets. The skill ratio that we use in this section is the traditional measure based on education of the employee; skilled labor being those having more than high school education and unskilled are those with high school or less than high school level of education.

Table 2.6 shows the estimation of equation 2.5. From columns 1 and 2 we see that average wage and skill ratio differentials changes are 1.5% and 3.6%, respectively, higher for firms offshoring to China in 2002 compared to the control group. Columns

3 indicate, interestingly, that there is no statistically significant change in sales per employee. If sales per employee is taken as a proxy for revenue based rent sharing then this result implies that skill composition is the only channel through which wages are affected, due to offshoring, between treatment and control firms in this period. Column 4 indicates that imports from China as share of sales (offshoring) are higher for treatment firms than for control firms during the 2002-2005 time period, showing that Danish firms offshoring to China in 2002 are better able to take advantage of the liberalized business environment in China and hence the fall in the cost of offshoring to China[16, 17]. However, though Chinese trade has become important for Denmark over the years, it constitutes about 5% of manufacturing imports. One possible worry is that the increased share of imports from China comes at the expense of reduced imports from rest of the world. For example, the Danish firms that had already offshored production abroad may now relocate these activities to China. Though this is not increased offshoring (since the activity has been offshored already), there can still be rent sharing effects from reduced costs and increased revenues and profits. Back of the envelope calculations show that Denmark's average annual growth rate of imports from China was 3.6% in 1999-2002 and increased to 55% in 2002-2005 period. For imports from rest of the world except China the respective growth rates of imports in the two periods were 3% and 17%. Based on this evidence we can safely conclude that the observed increase in imports from China is not accounted for by reduced imports from rest of the world.

[16]This value of imports includes all imports. In the robustness test we have constructed a narrower measure of imports by excluding primary inputs as a proxy for offshoring. Results are same using the narrower measure. In this paper we show results using only the braod measure of offshoring including imports of primary inputs.

[17]The control group includes non-offshoring firms, inflating the effect if they do not choose to offshore during the period. On the other hand, some of them could choose to offshore in 2003, 2004 or 2005, which could imply arbitrarily large jumps in import shares (from zero to something) compared to the treatment firms that mostly offshored to somewhere else than China at the beginning of 2002. Thus, presence of non-offshoring firms in the control group could also understate the effect. However, excluding these (few) non-importing manufacturers does not change results much. Thus, for consistency we decide to stick to the same sample as for the other estimations in Table 2.6.

Since the number of firms importing from China has increased over the years, we carry out the difference-in-differences estimation over 2002-2005 by breaking down types of firms depending on when they were offshoring to China and see if any differential results emerge among the different types of firms. Table 2.7 shows our findings; the types we are interested here are firms offshoring to China both in 2002 and 1999 (existing offshorers); firms offshoring to China in 2002 but not in 1999 (new offshorers); firms offshoring to China in 1999 but not in 2002 (former offshorers); firms offshoring to low middle-income countries but not China and non-importing firms (the omitted group). The results in Table 2.7 show that the firms offshoring to China in 2002 but not in 1999 experience the highest differential wage increases. Firms present in China in both 1999 and 2002 also show increase in average domestic wages in this period but less than the firms new to sourcing inputs from China. Just as in Table 2.6, column 3 in Table 2.7 indicates no differential labor productivity (sales-per-employee) changes between the different types of firms in the 2002-2005 period.

Since China's joining the WTO was anticipated, we may worry that our treatment firms are responding to the shock by changing their technology before 2002 to take better advantage of cheaper Chinese resources and this might lead to higher wages by increasing labor productivity. The findings in Table 2.7 alleviate that worry. Though the accession was anticipated, there was quite a lot of uncertainty in Denmark about the suitability of offshoring to China, apart from the various restrictions that were not to be dismantled till after China joined WTO. It is likely that this uncertainty prevented firms from increasing the level of offshoring to China in anticipation of the future changes. Hence, although firms could foresee new offshoring opportunities due to the long drawn WTO negotiations, it is unlikely that they could take advantage of it before the liberalizations actually came into effect. The results in column (4) provides support to this idea; since the change in offshoring was higher for the two types of firms importing from China in 2002[18], compared to the omitted group, we can conclude that both types of offshoring firms responded to the shocks by increasing the share of imports from China in the 2002-2005 period. The results in this table also indicate that the wage increases we witness in Table 2.6 are most pronounced for the firms that decide to offshore to China around 2002. This finding coupled with results in descriptive statistics in Table 2.2 lends support to the idea that China's accession to the WTO and the soon after surge in Chinese exports was more important for the relatively smaller and less productive firms who could not take advantage of Chinese imports prior to 2002 because of restrictive business environment in China; they began offshoring to China once China joined the WTO and also saw a surge in exports soon after.

To ensure that the results observed in Table 2.6 and Table 2.7 are indeed driven by the shock and not by differential trends between the more productive treatment firms compared to the less productive control firms, we need to check that the observed change in the outcome variables was greater during the period 2002-2005 than in other periods. We consider the pre-shock period to be 1999-2001. We estimate an equation similar to equation 2.6, taking the difference in the change in the outcome variable of interest over 2002-2005 from 1999-2001 and regressing it on the three types of firm dummies. This essentially leads to a triple-differences strategy which purges any differential trend for the firms. Results in Table 2.8 indicate that the differential change in average wage is the largest for firms new to offshoring from China in 2002. Average wage changed 3.6% more for these firms in the 2002-2005 period than in the 1999-2001 period compared to control firms. Skill ratio changes—though positive—are not significant. Differential change in sales per employee between the two periods is not significant either for the new offshoring firms compared to the omitted group. To sum up, though we find that events in China caused differential outcomes in 2002-2005 between the treatment and the control firms over and above

[18] These are firms continuing offshoring from China, and firms new to offshoring from China.

their basic underlying trend differences, using crude proxies for skill composition and rent sharing cannot explain what is driving the observed differential wage increase. Since skill includes much more than education and rent sharing might not just mean sharing revenue, we now use information on workers' wage histories in our worker-firm data to construct more rigorous measures of skill composition and rent sharing effects.

2.5.2 Estimating the Effects from a Worker-Firm Regression

We first estimate a standard AKM-type model — equation 2.2 — with time-varying firm effects. The inclusion of time varying firm effects allows us to address changes in firm wage policies following trade shocks. As time varying returns to individuals we include linear and quadratic terms for experience and age, and education (high skill: tertiary education; medium skill: vocational education; omitted group: high school or less). Table 2.9 shows the estimates from our worker-firm regression. As expected, more years of experience are associated with higher wages and there are diminishing returns to experience. Similar results are also true for age. Unsurprisingly, high-skilled workers and medium skilled workers earn more than low—or unskilled—workers.

We then estimate the effect of the shock on firm level average wage through the two effects constructed from the worker-firm regression using estimation equations 2.5 and 2.6. Table 2.10 presents results for difference-in-differences estimates for equation 2.5 over the 2002-2005 period. In this section we now find that average wages (deviated from annual mean) increased 1.2% more for firms offshoring to China in 2002 than control firms and both skill composition and rent sharing are responsible for this increase — both significant at the 10% level. Skill composition increased 0.3% more for firms offshoring to China in 2002 and explains about 25% of the wage increase. Rent sharing increased 0.9% more for firms offshoring to China in 2002 and accounts for as much as 75% of the wage increase.

To ensure that the difference we observe is indeed driven by the shock, we carry out a triple differences estimation similar to Table 2.8, by regressing the changes in our outcome variables of interest (firm level average wage, skill composition and rent sharing deviated from their respective annual means) between 2002-2005 and 1999-2001 periods, on the different firm dummies. The results for wages corroborate what we found earlier. Table 2.11 shows significant (at 10%-level) differential wage gains for firms new to offshoring from China (d_0_2002). Now we can say what is driving that wage differential: rent sharing only. Interestingly, for firms offshoring to China in both 1999 and 2002 (the existing offshoring firms), the differential gain in wages between the two periods is explained more by skill composition effect—rent sharing though positive is insignificant. For firms offshoring to China only before 2002, all the outcome variables have negative sign, though none are significant. The fact that wages increased differentially for the firms offshoring to China in 2002 is in line with the underlying theory. Moreover, we arrive at the apparent puzzle: the mechanisms behind the differential wage increase between the two periods (2002-2005 and 1999-2001) is different for the relatively smaller firms offshoring to China in 2002 but not in 1999, and the relatively larger firms offshoring to China in both 2002 and 1999. A glance at our data in Table 2.2 shows that the firms offshoring to China in 2002 and not in 1999 (d_0_2002) are smaller than firms offshoring to China in both 1999 and 2002 (d_1999_2002). Thus, the former firms are likely to have more homogeneous workers in terms of skill over the years and that could explain why their differential change in skill composition between the two periods is small. Bigger firms continuing to offshore to China are likely to have more diverse workforce hence their wage increase is accounted for by both mechanisms. Again, comparing results in Table 2.8 and Table 2.11 suggest that using measures of skill composition and rent sharing using worker-firm matched data allows us to take into account aspects of average wage determination that is not captured by traditional measures of skill based on education, and rent sharing based on revenue sharing.

2.6 Robustness Checks

In this section we carry out different robustness tests to strengthen our main results[19].

As a first check we re-estimate our main equation using alternate firm dummies, to see whether there was any differential wage effect for firms who began offshoring from China between 2003-2005, though their decision to do so was possibly endogenous. The firm types that we consider are d_2002: firms offshoring to China in 2002; and d_2003_2005: firms offshoring to China after 2002, i.e. sometime in 2003-2005 period but not doing so in 2002; the omitted group are firms not offshoring to China between 2002-2005 but offshoring to other low-middle income countries and non-offshoring firms. Table 2.12 provides qualitatively similar results for the firms offshoring to China in 2002 (d_2002) as found in Table 2.6. Both skill composition and rent sharing effects explain the higher change in wages and the latter channel explains more of the increase for these firms. We also see that there are wage gains for firms offshoring to China after 2002, mostly via the skill composition effect, so firms that began offshoring to China later have also gained. Table 2.13 presents a triple differences estimate by comparing the differential change in the change in our outcome variables of interest over 1999-2001 period and 2002-2005 period. The results indicate that there are differential gains in wages between the two periods for both types of firms, and both channels matter.

We carry out our main estimation using manufacturing firms only. We re-run the main estimations with all firms: manufacturing, services and retail/wholesale firms. The reason is twofold: first, our data reveals that firms switch status over the years; so a manufacturing firm might become a service or retail firm by offshoring its

[19]We have looked at the impact of the shock on other firm level variables such as employment and sales. We find that the differential increase in employment and sales was less at the treatment firms compared to the control firms (tables not reported). These results confirms the hypothesis that the shock from China did affect the treatment firms in different dimensions.

manufacturing operations. These firms would drop from our manufacturing sample and thus might lead to under-estimation of the effects of offshoring on our variables of interest. Second, the impact of the shock was also very pronounced for non-manufacturing firms as discussed in section 4.1. The results, displayed in Table 2.14, are consistent with our main results presented in Table 2.11, though coefficient estimates are now larger. We see there was wage gain for firms offshoring to China in 2002, and relatively more of that increase is explained through rent sharing. Triple differences estimation results in Table 2.15 again show that most of the differential increase is for the firms importing from China in 2002 but not 1999, but now only skill composition effects significantly explain that increase, and just roughly half of the differential gain. The other half explained by rent sharing is not statistically significant. There is also differential increase in wages observed for the firms importing from China in 2002 and in 1999, and that increase is still explained only through the skill composition effect and completely dominate the total effect on average wages.

What if the effects we see are not from the firms' new activities in China but instead from offshoring to other, similar countries? That is a very relevant concern. We have run our procedures on other similar countries and former Eastern European countries among which many are now part of the EU[20] and not low-income countries anymore. We find no results. Recall that we have a well-sustained argument for an unanticipated shock for Danish firms, particularly for small firms—even though China's accession was anticipated. In fact, running our regressions on a subsample of small firms—10-50 employees—show even stronger average effects. We see no other shocks, (for example the addition of many East European countries to the EU in 2004) of arguably the same scale. Table 2.16 shows that there is no differential impact for firms offshoring to Czech Republic in 2002 compared to the omitted group[21]. The

[20]A lot of these East European countries such as Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia joined the EU in 2004.

[21]The different groups are created the same way as before, now the relevant country for offshoring is Czech Republic instead of China. For example continuing offshorers in Table 2.16 are firms

case of the Czech Republic demonstrates nicely why effects must come from China's accession to the WTO acting as an unanticipated shock: very few of the treatment firms also offshore to the Czech Republic. The reason is that many of the firms are relatively new to offshoring and have few common source countries apart from China (see Table 2.18).

In 2005, growth in imports from Eastern European countries starts to pick up lowering the ratio of imports from China relative to Eastern European imports. To exclude this possible source of gains from offshoring to countries other than China from our results on the treated groups we run the estimations with the shock period defined as 2002 to 2004 instead of 2002 to 2005. The baseline results hold and estimates are—perhaps contrary to one's a priori beliefs—generally higher (see Table 2.19). Combined with the robustness check from other countries just discussed above in this section, we are confident that our results stem from the opening up of China as a sourcing destination and the dominating shock for our treatment groups. We do still refer to the results based on 2002-2005 as our main results because growth in imports from China still dominates any other sourcing destination in 2005 and thus define by when imports from China in an absolute amount truly takes off.

2.7 Conclusion

This paper uses rich linked worker-firm data from Denmark to address how offshoring affects firm level average wage. We use China's accession to the WTO in December 2001 and the boom in Chinese exports soon after, as exogenous shocks to the incentive to offshore to China by Danish firms. These shocks allow us to identify the causal effect of offshoring on wages.

Unlike other papers in this literature, we consider different possible channels — namely skill composition and rent sharing effects — to explain offshoring induced

offshoring to Czech Republic in 2002 and in 1999.

gains in firm average wages. A skill composition effect increases average wage if firms send low-skilled jobs abroad retaining high-skilled workers at home who require higher pay. A rent sharing effect increases average wage if firms share offshoring induced increase in profits with all existing worker. Our findings show that firms sourcing from China in 2002 had higher increase in average wages between 2002 and 2005 compared to the control group[22].

We find that both skill composition and rent sharing effects significantly matter in explaining the wage gain. Moreover, it is important to separate out the effects of the two channels since they have different policy implications. While the presence of the skill composition effects does underline that Danish firms offshore certain jobs, the presence of the rent sharing effect highlights that firms offshoring to China also enjoy increased profitability and share that with employees. The important result to highlight here is that the timing of when a firm is exposed to a shock to the incentive to offshore matters. In our case: firms present in China before China's accession to the WTO in December 2001 offshored jobs using relatively unskilled labor. Whereas, firms not present in China before the time of accession increased profitability and shared these increases with their employees, thus pointing to increased welfare. These firms however did not offshore relatively more any particular skill type of job. One possible explanation for this could be the size difference of the two types of firms and hence their workforce composition. Smaller manufacturing firms (less than thirty employees) are likely to have more homogeneous workforce and for them the average skill level of the workers might not change much over the years. Bigger firms already offshoring to China are likely to have more diverse workforce and hence for them both composition and rent sharing matter for the wage increase. However, the skill composition effect significantly explains about half that gain while the other half explained by the rent sharing effect is not statistically significant.

[22]Control group consists of firms offshoring to low middle income countries but not China and non-offshoring firms.

Though we carry out estimations at the firm level, we fully utilize the worker-firm match data. Following Frias, Kaplan & Verhoogen (2009) we decompose the effects on average wages into estimated effects due to skill composition changes and changes due to rent sharing. We compare these results with results obtained using measures of skill composition and rent sharing available from typical firm level data. We show that using linked worker-firm data allows us added insight behind the wage increase mechanism because, in our case, the two sets of results do not conform; ratio of educated to uneducated workers as a traditional measure for skill composition and sales per employee as a measure of rent sharing cannot explain the average wage increase. Our measure of composition and rent sharing constructed from the worker level wage regression of the AKM type do.

Table 2.1: Comparing characteristics between offshoring and non-offshoring firms (2005)

	All firms	Offshoring firms	Non-offshoring firms	Regr. Mean difference
No. of firms	5281	3007	2274	
Means				
Log (employees)	3.41	3.78	2.93	0.85***
	(1.00)	(1.09)	(0.56)	(0.02)
Log (sales)	17.05	17.70	16.19	1.20***
	(1.36)	(1.31)	(0.87)	(0.03)
Skill ratio, edu/non-edu	3.65	3.76	3.50	0.26**
	(3.88)	(4.15)	(3.47)	(0.11)
Log (EBIT per worker)	10.83	11.08	10.51	0.36***
	(1.10)	(1.12)	(0.99)	(0.04)
Log (hourly wage)	5.20	5.25	5.14	0.06***
	(0.19)	(0.17)	(0.21)	(0.01)

Note: Educated (edu.) means have more than high school education and non-educated (no edu.) refers to less than or equal to twelve years of education. The last column gives difference in the means between offshoring and non-offshoring firms; all regressions include industry fixed effect and employment is included as additional control in all regressions except log(employees).*** implies $p<0.01$.

Table 2.2: Comparison of firm characteristic by type in 2002

	wage	sales/emp	sales	emp
Existing Offshoring Firms	0.082***	0.621***	2.18***	1.56***
	(0.012)	(0.041)	(0.112)	(0.096)
New Offshoring Firms	0.049***	0.55***	1.88***	1.33***
	(0.016)	(0.054)	(0.128)	(0.116)
Former Offshoring Firms	0.084***	0.682***	2.12***	1.44***
	(0.03)	(0.143)	(0.251)	(0.235)
N	3336	3337	3337	3337

Note: Robust standard errors in the parenthesis. All regressions includes industry fixed effects. The omitted group is firms not offshoring to China but offshoring to other low-middle income countries and non-offshoring firms in 1999/2002.*** implies p<0.01.

Table 2.3: Comparison of HS6 manufacturing imported consumption goods between 2002-2005 and 1999-2001

(a) HS6 Manufacturing imported consumption goods (2002-2005)

HS Code	Description	2005	2002
160540	Crustaceans nes, prepared or preserved	53340799	1311804
711719	Imitation jewellery nes of base metal including plate	43417328	9816229
940360	Furniture, wooden, nes	38544723	1117227
030420	Fish fillets, frozen	33941755	3303811
620333	Mens, boys jackets, blazers, synthetic fibre, not kni	33804627	179689
620343	Mens, boys trousers shorts, synthetic fibre, not knit	32858528	12386218
392690	Plastic articles nes	26146710	17187523
940179	Seats with metal frames, nes	24050163	908627
950390	Toys nes	23540912	5684666
940490	Articles of bedding nes	21799778	8238720

(b) HS6 Manufacturing imported consumption goods (2001-1999)

HS Code	Description	2001	1999
392690	Plastic articles nes	18687247	6150690
610711	Mens, boys underpants or briefs, of cotton, knit	16505069	18054200
030420	Fish fillets, frozen	14937704	136284
620343	Mens, boys trousers shorts, synthetic fibre, not knit	14733910	2602090
902190	Orthopaedic appliances, nes	12922589	6737316
950330	Construction sets and constructional toys, nes	11641092	3671195
040900	Honey, natural	9237678	4331478
030619	Crustaceans nes, frozen,	9110324	6118847
420231	Articles for pocket or handbag, leather outer surface	8706212	4630337
841840	Freezers of the upright type, $<$ 900 litre capacity	8292136	1909480

Source: External firm level trade statistics, Statistics Denmark, own calculations Notes: Amounts are in DKK. Classification of consumption goods and intermediate goods follow the BACI classification from CEPII. Rank gives the position of the commodity in DKK in the year 2002 and 1999.

Table 2.4: Comparison of HS6 manufacturing imported intermediate goods between 2002-2005 and 1999-2001

(a) HS6 Manufacturing imported intermediate goods (2002-2005)

HS Code	Description	2005	2002
848180	Taps, cocks, valves and similar appliances, nes	126744085	31182357
870839	Brake system parts except linings for motor vehicles	107457536	34315
848190	Parts of taps, cocks, valves or similar appliances	99517689	71550756
853400	Electronic printed circuits	82899720	39798006
732510	Cast articles, of non-malleable cast iron nes	62931197	1049846
841391	Parts of pumps for liquids	49542779	44151963
730723	Pipe fittings, butt welding of stainless steel	47028226	10519817
350790	Enzymes nes, prepared enzymes nes, except rennet	45636175	20757774
940390	Furniture parts nes	40444629	5836004
852990	Parts for radio/tv transmit/receive equipment, nes	39835005	3784459

(b) HS6 Manufacturing imported intermediate goods (2001-1999)

HS Code	Description	2001	1999
851822	Multiple loudspeakers, mounted in single enclosure	114262840	32312257
760429	Bars, rods and other profiles, aluminium alloyed	67087534	
841391	Parts of pumps for liquids	56487117	29320032
853400	Electronic printed circuits	40652653	3689736
851890	Parts of non-recording electronic equipment	35982391	6541136
848180	Taps, cocks, valves and similar appliances, nes	34947270	150615
848190	Parts of taps, cocks, valves or similar appliances	33820169	5482547
851829	Loudspeakers, nes	28085847	343302
850431	Transformers electric, power capacity $<$ 1 KVA, nes	27948139	586888
730729	Pipe fittings of stainless steel except butt welding	26270529	46720486

Source: External firm level trade statistics, Statistics Denmark, own calculations Notes: Amounts are in DKK. Classification of consumption goods and intermediate goods follow the BACI classification from CEPII. Rank gives the position of the commodity in DKK in the year 2002 and 1999.

Table 2.5: Decomposing growth rate from China by intensive and extensive margin

(a) Decomposing imports from China (2002-2005)

	Change (M DKR)	share of increase Extensive	Intensive
Consumption	489	25%	75%
Intermediate	795	37%	63%
Total	1284	32%	68%

Source: External firm level trade statistics, Statistics Denmark, own calculations Notes: Classification of consumption goods and intermediate goods follow the BACI classification from CEPII. Low/med income group excludes China.

(b) Decomposing imports from China (2002-2005) by firm types

	Offshoring to China in 2002			Offshoring to China in 2003-2005		
	Change	Share of increase		Change	Share of increase	
	(M DKR)	Extensive	Intensive	(M DKR)	Extensive	Intensive
Consumption	350	30%	70%	139	100%	0
Intermediate	426	39%	61%	369	100%	0
Total	776	35%	65%	508	100%	0

Source: External firm level trade statistics, Statistics Denmark, own calculations.

Notes: Classification of consumption goods and intermediate goods follow the BACI classification from CEPII. Last column contains firms offshoring to China in 2003-2005 period but not 2002.

Table 2.6: Difference-in-difference estimates (2002-2005)

	(1)	(2)	(3)	(4)
	Δ(avgwage)	Δ(sk_ratio)	Δ(sales/emp)	Δ(offshore)
Offshoring in 2002	0.015***	0.036***	0.011	0.010***
	(0.005)	(0.011)	(0.02)	(0.002)
N	2119	2119	2119	2119

Note: Robust standard error in the parenthesis. All regressions include industry fixed effects. ***,**,* indicate significance at 1,5,10 percent levels respectively. Dependent variable is differenced over 2002-2005 period.

Table 2.7: Difference-in-difference estimate by firm types (2002-2005)

	1	2	3	4
	Δ (avgwage)	Δ (sk_ratio)	Δ(sales/emp)	Δ(offshore)
Existing Offshoring	0.015**	0.048**	0.003	0.02***
Firms	(0.006)	(0.020)	(0.028)	(0.005)
New Offshoring	0.027***	0.041*	0.005	0.013***
Firms	(0.009)	(0.022)	(0.040)	(0.004)
Former Offshoring	0.003	0.006	-0.061	0.004
Firms	(0.016)	(0.033)	(0.106)	(0.002)
N	1915	1761	1915	1915

Note: Robust standard error in the parenthesis. All regressions include industry fixed effects. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.8: Triple difference estimate by firm types

	1	2	3	4
	Δ (avgwage)	Δ (sk_ratio)	Δ(sales/emp)	Δ(offshore)
Existing Offshoring Firms	0.007	0.019	0.000	0.018***
	(0.009)	(0.017)	(0.038)	(0.006)
New Offshoring Firms	0.036***	0.013	0.019	0.014***
	(0.012)	(0.021)	(0.059)	(0.005)
Former Offshoring Firms	0.002	-0.008	-0.172	0.022**
	(0.022)	(0.040)	(0.133)	(0.01)
N	1293	1293	1293	1293

Note: Robust standard errors in the parenthesis. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.9: Worker level wage regression

dep var	age	age_sq	experience	experience_sq	high_sk	med_sk
wage	0.041***	-.0003***	0.010***	-0.0003***	0.460***	0.395***
	(0.0004)	(0.000)	(.0003)	(0.000)	(.0106)	(.007)

Note: Standard errors in parenthesis estimated with 50 bootstrap replications, clustering at level of individuals. The regression includes time fixed effects. ***,**,* indicate significance at 1,5,10 percent levels respectively. Number of observations 1106744.

Table 2.10: Difference-in-difference estimate using measures constructed from worker level wage regression (2002-2005))

	(1)	(2)	(3)
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Offshoring in 2002	0.012**	0.003*	0.009**
	(0.005)	(0.002)	(0.004)
N	1742	1742	1742

Note: Robust standard errors in the parentheses. All regressions include industry fixed effects. **,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.11: Triple difference estimate using measures constructed from worker level wage regression by firm types

	1	2	3
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Existing Offshoring Firms	0.012*	0.008*	0.005
	(0.007)	(0.004)	(0.008)
New Offshoring Firms	0.018*	0.001	0.017*
	(0.01)	(0.005)	(0.01)
Former Offshoring Firms	-0.027	-0.019	-0.008
	(0.024)	(0.02)	(0.015)
N	1272	1272	1272

Note: Robust standard errors in the parenthesis. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.12: Difference-in-difference estimates using alternate firm types (2002-2005)

	1	2	3
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Offshoring in 2002	0.013**	0.005*	0.008*
	(0.005)	(0.003)	(0.004)
Offshoring after 2002	0.011*	0.002	0.009*
	(0.007)	(0.004)	(0.006)
N	1742	1742	1742

Note: Robust standard error in the parenthesis. All regression includes industry fixed effects. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.13: Triple difference estimates using alternate firm types

	1	2	3
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Offshoring in 2002	0.016**	0.007**	0.009*
	(0.007)	(0.004)	(0.006)
Offshoring after 2002	0.017*	0.009*	0.008
	(0.010)	(0.005)	(0.009)
N	1483	1483	1483

Note: Robust standard error in the parenthesis. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.14: Difference-in-difference estimate using manufacturing and non-manufacturing firms (2002-2005)

	(1)	(2)	(3)
	Δ(avgwage)	Δ(sk_comp)	Δ(rent_sh)
Offshoring in 2002	0.018***	0.005*	0.013***
	(0.004)	(0.003)	(0.004)
N	6253	6253	6253

Note: Robust standard errors in the parenthesis. All regressions include industry fixed effects. ***,**,* indicate significance at 1,5,10 percent levels respectively. Dependent variable is differenced over 2002-2005 period.

Table 2.15: Triple difference estimate using manufacturing and non-manufacturing firms

	1	2	3
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Existing Offshoring	0.01*	0.012**	-0.002
Firms	(0.006)	(0.004)	(0.005)
New Offshoring	0.02**	0.012*	0.009
Firms	(0.01)	(0.007)	(0.08)
Former Offshoring	-0.026*	-0.013	-0.013
Firms	(0.013)	(0.012)	(0.013)
N	6808	6808	6808

Note: Robust standard errors in the parenthesis. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.16: Triple difference estimates using firms offshoring to Czech Republic

	1	2	3
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Existing Offshoring	0.012	0.003	0.010
Firms	(0.011)	(0.006)	(0.010)
New Offshoring	0.002	-0.004	0.006
Firms	(0.011)	(0.005)	(0.010)
Former Offshoring	0.014	0.002	0.011
Firms	(0.019)	(0.011)	(0.015)
N	1468	1468	1468

Note: Robust standard errors in the parenthesis. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Table 2.17: Firm's share of imports coming from China (CN) between 1999 and 2005

	No. of firms*	1999	2001	2002	2005
Firms not present in CN in 2002	402	16%	10%		15%
Firms not present in CN in 2002 but not in 1999	294		5%	6%	13%
Firms present in CN in 2002	1803	16%	17%	15%	22%
Firms present in CN before, in, and after 2002	805	16%	20%	20%	26%
Firms present before 2002 and again in 2005	45	11%	4%		8%

* Based on 2002

Source: Statistic Denmark's firm level external trade statistics, authors' calculations

Table 2.18: Danish firms importing from China (CN) and the Czech Republic (CZ)

No. of manufacturing firms	Imports from CN..		Imports from CZ..	
	..in total	..and not CZ	..in total	..and not CN
Importers in 2002	3995	3391	1637	287
Importers in 2005	7033	6539	872	98
Not importing from either two in 2002	3015		3015	
New to import from source	3038	580	-765	14

Note: CN stands for China and CZ for Czech Republic

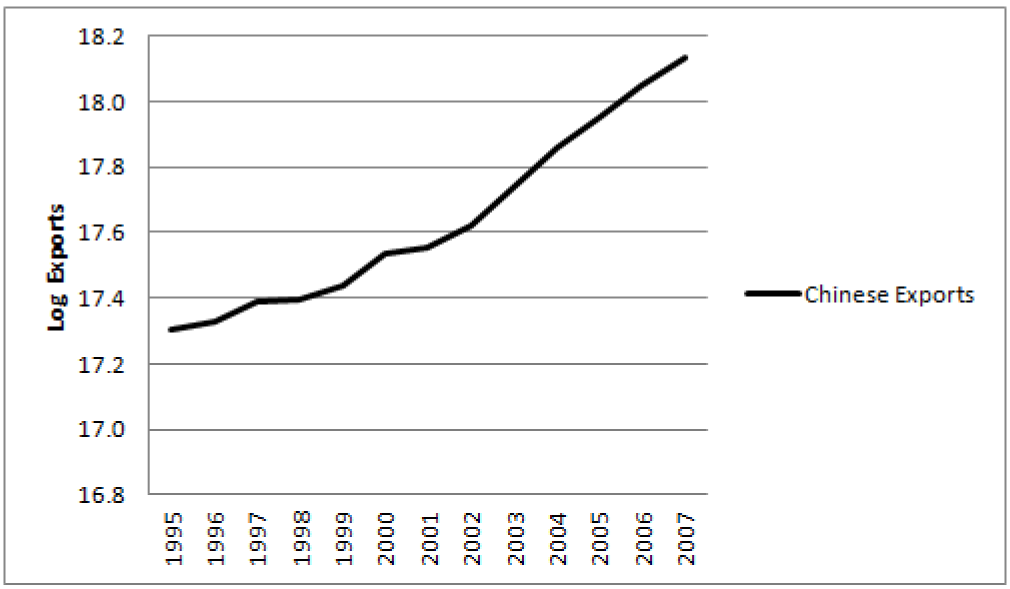
Source: Statistic Denmark's firm level external trade statistics, authors' calculations

Table 2.19: Triple difference estimates using 2002-2004 as the shock period

	1	2	3
	Δ avg_wage	Δ sk_comp	Δ rent_sh
Existing Offshoring Firms	0.014*	0.006	0.008
	(0.007)	(0.004)	(0.007)
New Offshoring Firms	0.0192*	0.001	0.018*
	(0.01)	(0.005)	(0.09)
Former Offshoring Firms	-0.027	-0.015	-0.005
	(0.024)	(0.02)	(0.016)
N	1360	1360	1360

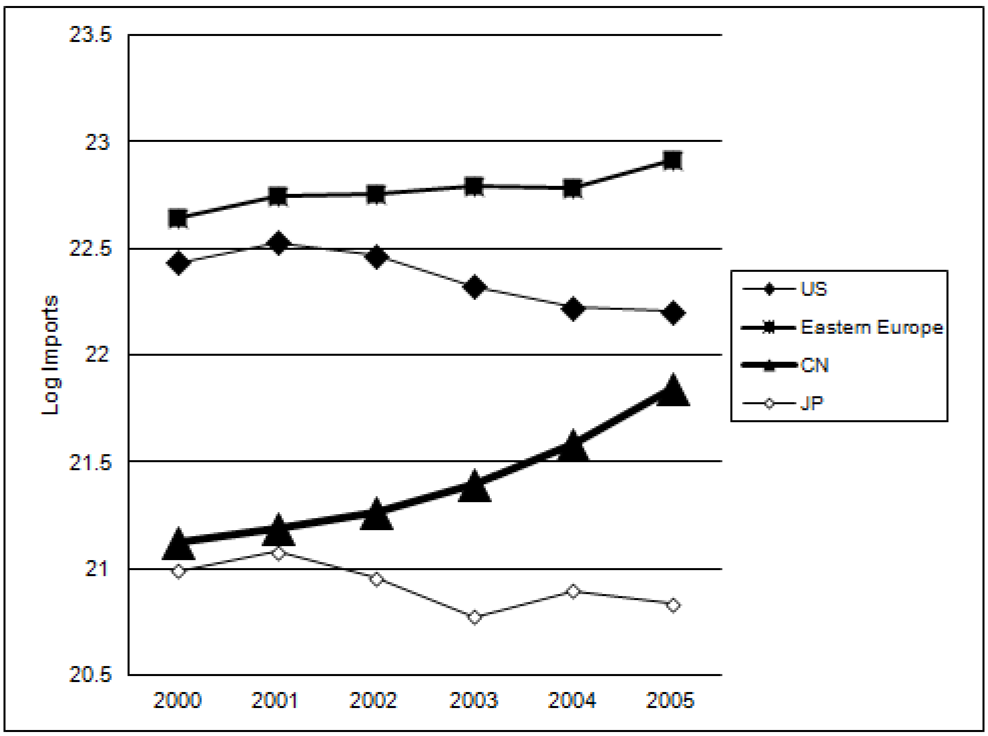
Note: Robust standard errors in the parenthesis. ***,**,* indicate significance at 1,5,10 percent levels respectively.

Figure 2.1: Chinese exports excluding Denmark (1995-2007)



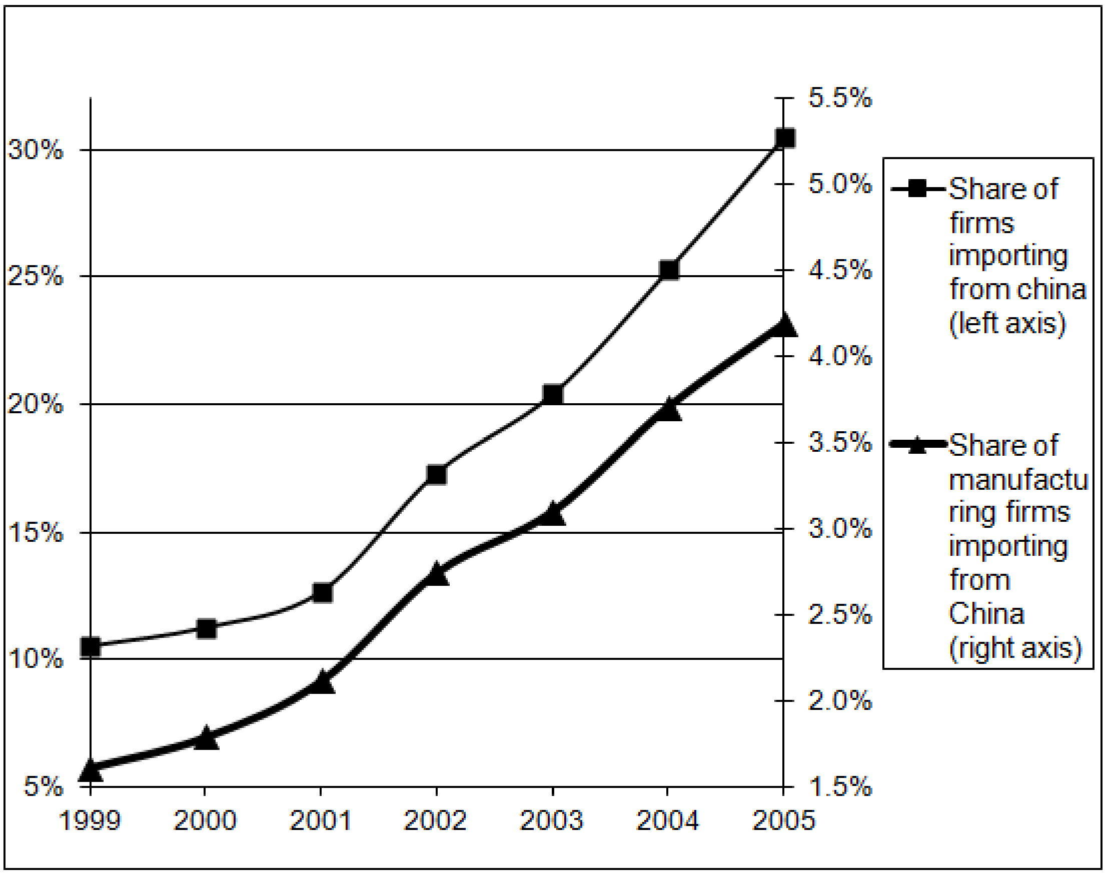
Note: Authors' Calculation using Comtrade data

Figure 2.2: Danish manufacturing imports from selected partners



Note: Growth rates of imports from China are between two and ten times the growth rates of imports from Eastern Europe between 2002 and 2005. Source: External firm level trade statistics, Statistics Denmark, own calculations

Figure 2.3: Share of Danish firms sourcing from China (1999-2005)



Source: External firm level trade statistics, Statistics Denmark, own calculations Note: Values on left hand axis relate to share of all firms importing from China. Values related to share of manufacturing firms importing from China are on the right hand axis.

Chapter 3

Offshoring and Wages with Heterogeneous Firms and Workers: A Theory Perspective

3.1 Introduction

Offshoring[1] firms are found to pay higher average wages[2]. A wide array of papers have looked at the impact of offshoring on wages[3]. However, a crucial question remains unanswered: whether the higher wages is due to a change in the composition of workers as a result of offshoring (skill composition effect) or because all existing workers get higher pay (rent sharing effect) due to offshoring. This paper aims to fill this gap by building a theory model that decomposes the wage effects of offshoring into the two effects — those attributed to a change in composition of the workforce and those attributed to a change in rent sharing. Understanding how these two

[1] Offshoring refers to relocating jobs from the home country to the foreign country.

[2] (Bernard et al. 2007).

[3] Feesntra and Hanson (1999), Hummels et al. (2009), Kramarz (2008), Sethupathy (2008) to name a few.

effects come into play is important for making policy decisions in the current scenario of booming offshoring of both manufacturing tasks and other business functions.

This paper extends the Sethupathy (2008) model by introducing heterogeneous workers to consider the firm-level impact of offshoring on wages through the two channels (composition effect and rent sharing effect). The key features of the model are as follows. First, there are heterogeneous labors who vary at the skill level. I assume that there are two types of workers — high-skilled and low-skilled. Second, the labor market is imperfect. There is wage bargaining between firms and each type of worker that yields rent sharing wage specifications. In particular, the wage of each type of worker comprises of a share of firm specific rents (as a share in the firm's operating profits) and a common outside option. Third, firms vary in terms of productivity a la Melitz (2003). Fourth, there is opportunity for offshoring each type of task (high-skilled and low-skilled)[4], requiring a marginal cost that varies with the degree of non-routineness of the task and a fixed cost. The presence of heterogeneous firms coupled with fixed cost of offshoring implies that only the most productive firms would select into offshoring, whereas the less productive firms would be sourcing solely from the domestic market. Fifth, the demand specification follows Melitz and Ottaviano (2008) leading to endogenous markups. New offshoring opportunities reduce the marginal cost of production and thus increase the firm's profitability. The offshoring induced higher profits, due to the rent sharing wage specification, gets translated into higher wages of all domestic workers leading to higher firm level average wages. Moreover, if one type of task is offshored relatively more than the other then that would change the domestic composition of workers in the firm and affect the average wage. For example, if firms are offshoring low-skilled, low paid jobs then the average domestic wage would automatically increase with offshoring. The interaction of the rent sharing effect and the skill composition effect would determine how average wages are affected by an increase in offshoring opportunity. Following Sethupathy (2008), in this paper I model

[4]The offshoring setup follows Grossman and Rossi-Hansberg (2008) model.

the effects of marginal liberalization which has better scope for empirical testing than a move from autarky to full offshoring. The main prediction of the model is that a fall in the cost of offshoring increases average wage in the offshoring firm due to a rent sharing effect. This effect can be further reinforced or weakened by an accompanying skill composition effect. The average wages in the non-offshoring firms decline due to a rent sharing effect only; there is no skill composition effect for these firms in the model.

3.2 The Model

3.2.1 Production and Offshoring Technology

There are two types of labor in this model, high-skilled labor denoted by N_H and low-skilled labor denoted by N_L. The economy produces two goods: X and Y, where Y is the homogeneous goods sector and is characterized by perfect competition in both the product and the factor markets. Y is produced using both types of labor under a simple constant returns to scale technology[5]. The two factors act as perfect substitutes in the production of Y. The homogeneous goods sector acts as the numeraire and there is no scope for offshoring in this sector.

Sector X is the differentiated goods sector and faces imperfections in the factor market and monopolistic competition in the product market. Production of X requires both high-skilled and low-skilled labor, and I assume that there is no possibility of substitution between the two factors. Firms pay a fixed entry cost (f_e) to learn their productivity parameter from the distribution $G(\phi)$. Once a firm makes a productivity draw it then acts in two stages. In the first stage firms and workers bargain with each other and set the wages. In the second stage, given the wages from the first stage, firms maximize profits in a monopolistically competitive product

[5] We can assume $Y = N_H + \alpha N_L$, where $\alpha \leq 1$, take $\alpha = 1$ for simplicity.

market. At this stage firms that expect to make negative profits will exit.

The production of a unit of good in sector X requires a continuum of low-skilled tasks (referred to as L-tasks) and a continuum of high-skilled tasks (H-tasks). The former tasks are performed by low-skilled labor only and the latter only by high-skilled labor i.e. substitution between the different tasks is not allowed in this model. Without loss of generality the measure of tasks employing labor of type-f is normalized to equal one and indexed by $z_f \,\epsilon\, [0,1]$ where $f = \{L, H\}$. Firms can undertake to perform the tasks at home or abroad. Tasks can be performed offshore either within or beyond the boundaries of the firm. The factor requirement is assumed to be the same irrespective of the location of the tasks and the organizational form the firm chooses in the foreign market. In this paper, the continuum of tasks $z_{f\,,} f = \{L, H\}$, reflects that within skill types some tasks are easier to offshore than others; tasks being ordered so that the cost of offshoring is non-decreasing. It is assumed that low z_f tasks are easier to offshore. The cost of offshoring a task is not related to the skill level but instead, as in Grossman and Rossi-Hansberg (2008), reflects how difficult it is to describe using rules-based logic, how important it is that the task be delivered personally, and how difficult it is to transmit or transport the output of the activity etc[6].

The production function in sector X is given by:

$$X = \phi\, min\{\frac{N_H}{a_H}, \frac{N_L}{a_L}\} \tag{3.1}$$

where $N_f(\phi)$, $f = \{L, H\}$, stands for the employment of labor of type-f at a firm with productivity level ϕ. It is assumed that each type-f task requires an equal share ς_f of $N_f(\phi)$ which is same for all firms in sector X. It follows that $\varsigma_f N_f(\phi)$ units

[6]Blinder (2006) provides a discussion that the degree of offshorability of tasks is not related to the skill level of a task but rather on the nature of the task i.e. whether it is routine or non-routine. Leamer and Storper (2001) also distinguish tasks as those that require tacit information and are difficult to offshore and those that are codifiable and hence vulnerable to offshoring. Similarly, Autor, Levy, Murnane (2003) divide tasks on their degree of routineness, more routine tasks are easier to offshore compared to non-routine ones.

of type-f workers are employed to perform each task z_f in the task space. Thus z_f also captures the share of type-f labor doing tasks in the interval $[0, z_f]$ since ς_f is a constant.

The wage of type-f worker in the foreign country is w_f^* and is exogenous in this model. The cost of offshoring task z_f is given by $\beta_f t_f(z_f)\varsigma_f N_f w_f^*$. Offshoring a task is assumed to involve two additional costs. The first is $t_f(z_f)$ with $t_f'(z) > 0$, reflecting that as tasks become more non-routine it is more difficult/ costly to undertake the task from a distance irrespective of the skill level. To ensure that in equilibrium no firm chooses to offshore all tasks it is assumed that $Lt_{z \to 1} t(z) \to \infty$ (suppressing the f subscript), i.e. the most non-routine tasks cannot be separated from the home firm. There is also a policy related cost $\beta_f > 1$ which is the same for all firms offshoring type-f tasks and this represents the government regulation induced offshoring costs. In order to keep the following exposition simple, I will assume that $\beta_L = \beta_H = \beta$. Finally, firms in sector X can only offshore tasks, there is no trade in final goods in this sector.

3.2.2 Wage Determination

The homogeneous goods sector Y faces a perfectly competitive labor market. Workers receive their marginal product of labor $\bar{w}_y$ as wage[7]. This sector also absorbs the residual labor from sector X. The labor market clearing condition of labor of type-f is given by: $L_f = L_f^X + L_f^Y$; where L_f^X and L_f^Y are the demand for labor in sector X and Y respectively.

The labor market in sector X is not perfectly competitive and works in the following manner. First, all workers irrespective of their skill type start by searching for jobs in sector X with the knowledge that if they are unable to find one they can costlessly move to sector Y and earn $\bar{w}_y$. Workers and firms in sector X are randomly

[7]Note the assumption that the two types of workers are perfectly substitutable in the production of Y implies that they have the same marginal product of labor and hence get the same wage.

matched, however not all workers can find a successful match since labor supply exceeds labor demand in sector X for any type of worker. The unmatched workers in sector X are then absorbed in the other sector and receive a wage of $\bar{w}_y$. Anticipating the outcome of the bargaining game, in the second stage, the firms decide on their level of total employment of each type of worker, N_f, and the domestic employment N_f^d. I assume that for each type of worker there is a separate Nash-bargaining game for splitting the surplus created from the match between firms and workers. The surplus that accrues to the worker is the difference between wage earned at the firm and the worker's outside option, which is to work in sector Y and earn $\bar{w}_y$. Since all workers of type-f are exante identical they all agree or disagree to accept the job in the same manner. Hence I assume that each type of worker as a group bargains with the firm. The surplus for the firm is the profit earned by the union of the firm and the two types of workers. For the firm, it is assumed that if no agreement is reached between worker of a given type and the firm, then the latter fails to produce anything and earns zero profit (the disagreement pay-off)[8]. In particular the firm bargains with the two types of workers simultaneously assuming that the other type has agreed to the bargain. The Nash-bargaining game solved by worker of type-f and the firm is given by:

$$\max_{w_f} \theta_f \, ln[N_f^d(w_f, .)\,(w_f - \bar{w}_y)] + (1 - \theta_f)\, ln\Pi \tag{3.2}$$

where $\theta_f \epsilon\, [0, 1]$ is the exogenously given bargaining power of domestic worker of type-f (N_f^d) versus the firm; and Π is the operating profit of the firm and also firm's surplus from a successful bargaining. In the above set-up the firm only bargains over the wages for each type of worker. The level of employment, both at home and abroad, is determined in the second stage during product market competition[9]. Solving the

[8]This is because not all tasks can be offshored and each task needs to be performed to produce X.

[9]See Abowd and Lemieux (2003) for details on this type of bargaining set-up.

bargaining game gives the following rent sharing wage specification for worker of type-f:

$$w_f = \eta_f \frac{\Pi}{N_f^d} + \bar{w}_y \tag{3.3}$$

η_f[10] is the rent sharing parameter and is exogenous in this model. The details of derivation of the wage specification can be found in appendix B.1. The wage specification implies that for a given type of worker, a firm with higher operating profits per worker would be paying higher wages[11].

3.2.3 Demand

Consumer preferences follow the quasi-linear specification of Melitz and Ottaviano (2008) which generates endogenous mark-ups for firms. In an economy with L[12] units of consumers, the demand function can be written as:

$$U = q_y + [\rho \int_{i \epsilon I} q_i di] - [\frac{1}{2}\gamma \int_{i \epsilon I} (q_i)^2 di] - [\frac{1}{2}\lambda (\int_{i \epsilon I} q_i di)^2] \tag{3.4}$$

with the measure of set I representing the mass of goods produced in sector X. q_y and q_i represents the consumption of the homogeneous and the differentiated goods, respectively, by a consumer. The parameter ρ indexes the substitution between the differentiated good i and good Y. λ on the other hand, indexes the substitution between the aggregate good X and good Y. Lastly, γ indexes the degree of product differentiation among the differentiated goods in I. The quasi-linear utility function implies that there is no income effect for change in the consumption of the differentiated goods. The monopolistic competition framework means that each firm is a

[10] η_f is a function of θ_f and the wage elasticities with respect to N_f^d.

[11] Note that the firm size wage premium is ensured by the assumption that the firm's search cost associated with each type of worker, $b_f(\phi)$, is increasing in ϕ. In that case it can be shown that $w_f = b_f$ in equilibrium.

[12] L consists of total number of individuals in the economy, assuming that preferences are same irrespective of skill type.

monopolist in its own good but faces competition from other goods, which are imperfect substitutes since ($\gamma > 0$). The inverse demand function obtained from consumer's constrained optimization exercise can be written as:

$$p_i = \rho - \gamma q_i - \lambda Q_x \tag{3.5}$$

where Q_x gives the total consumption of the aggregate good X. The demand for the i^{th} good in sector X is obtained from the above equation as:

$$Lq_i = \frac{\rho L}{\gamma + \lambda M} - \frac{Lp_i}{\gamma} + \frac{\lambda M}{\gamma + \lambda M}\frac{L}{\gamma}\bar{P}_x \tag{3.6}$$

M stands for the measure of consumed varieties from the demand side (or the measure of firms from the production side) and $\bar{P}_x$ is the average price in sector X defined as: $\bar{P}_x = \frac{1}{M}\int_{i\epsilon I} p_i di$.

Next we define p_{max} as the price at which demand for a good reaches zero:

$$p_{max} = \frac{\rho\gamma}{\gamma + \lambda M} + \frac{\lambda M}{\gamma + \lambda M}\bar{P}_x \tag{3.7}$$

Any firm setting $p \geq p_{max}$ hits zero demand for the good and earns zero profits as well.

3.3 Benchmark Case of Limited Offshoring

3.3.1 Production under Limited Offshoring

Since a move from complete autarky to a fully open economy is not truly testable empirically, hence following Sethupathy (2008), I consider the benchmark case as one with limited offshoring and then go on to investigate the comparative static effects of a marginal liberalization. In sector$X$, there is a continuum of firms, each producing a different good, i. The firms in this sector would like to take advantage of cheaper wages abroad in the product market competition stage. However sending tasks abroad involves paying a common fixed cost, f_o, that is related to setting up production facilities abroad. Note that since the ensuing discussions are from the point of view of an individual firm so the subscript i will be dropped henceforth.

Since demand is linear, and p is decreasing in ϕ (shown in appendix B.2a), there exists a unique $\bar{\phi}$ such that $p(\bar{\phi}) = p_{max}$ and $\Pi(\bar{\phi}) = 0$. Hence, $\bar{\phi}$ serves as a cut-off to partition firms between those that exit ($\phi < \bar{\phi}$) and those that stay active ($\phi \geq \bar{\phi}$) and earn non-negative profits. Since the benefits from offshoring increase with scale, the fixed costs, f_o in terms of the numeraire good, partition firms into those that choose to offshore and purely domestic firms who source from home. Appendix B.4 proves the existence of and defines the productivity cut-off $\bar{\phi}_o$ that partitions firms into ones that offshore and ones that do not. The following summarizes the cut-offs separating the different types of firms in this model:

$$\begin{cases} \phi > \bar{\phi}_0 & \rightarrow \quad \text{offshore} \\ \bar{\phi}_0 \geq \phi \geq \bar{\phi} & \rightarrow \quad \text{produce domestically} \\ \phi < \bar{\phi} & \rightarrow \quad \text{exit} \end{cases}$$

Let $\bar{z}_f$ be the marginal task performed at home by factor-f. This cutoff is determined by the condition that the wage savings from sending the job abroad just balance the offshoring costs, making the firm's marginal cost of the offshored task the same as the marginal cost of performing that task domestically. For type-f labor this condition is:

$$\beta t_f(\bar{z}_f) w_f^* = w_f \tag{3.8}$$

where w_f is solved in equation 3.10. I assume that $\beta t_f(0) w_f^* < w_f$ for all firms so that if there were no fixed costs of offshoring, all firms would have found it profitable to offshore some jobs. Appendix B.3b demonstrates that in equilibrium, more productive firms offshore a higher share of both types of tasks. This happens because more productive firms pay higher domestic wages hence the scope for cost savings from offshoring any given task are also greater and hence they are able to move further up the $t_f(z_f)$ schedule.

Next, the total variable cost of the firm can be expressed as: $\tilde{w}_L N_L + \tilde{w}_H N_H$ where, $\tilde{w}_f = w_f(1-\bar{z}_f) + w_f^* \beta \frac{\int_0^{\bar{z}_f} t_f(\bar{z}_f)}{N_f}$ [13]. The marginal cost can be derived as: $c = \frac{\tilde{w}_L a_L + \tilde{w}_H a_H}{\phi}$ [14]. We can write operating profits per domestic worker of type-f as: $\pi_f = \frac{\Pi}{N_f^d} = \frac{pq-(\tilde{w}_L N_L + \tilde{w}_H N_H)}{N_f^d}$[15]. Using the above definitions and equations (3.3) and (3.8), I can solve for the key variables, π_f, w_f and c of a firm as:

$$\pi_f = \frac{p\phi - \tau_H a_H - \tau_L a_L - \bar{w}_y(\xi_L a_L + \xi_H a_H)}{a_f \xi_f (1+\tilde{\eta})} \tag{3.9}$$

$$w_f = \frac{p\phi\eta_f - (\tau_j a_j + \tau_f a_f)\eta_f + \bar{w}_y[(1+\eta_j)\xi_f a_f - \eta_f \xi_j a_j]}{a_f \xi_f (1+\tilde{\eta})} \tag{3.10}$$

$$c = \frac{\tilde{\eta} p\phi + \tau_H a_H + \tau_L a_L + \bar{w}_y(\xi_L a_L + \xi_H a_H)}{\phi(1+\tilde{\eta})} \tag{3.11}$$

where $f = \{L, H\}$, $j \neq f, \tau_f = w_f^* \beta \frac{\int_0^{\bar{z}_f} t_f(\bar{z}_f)}{N_f}$, $\xi_f = (1-\bar{z}_f)$ and $\tilde{\eta} = (\eta_H + \eta_L)$. The equilibrium values of firms that do not offshore is obtained by setting $\bar{z}_f = 0$ in equations 3.9-3.11. From the above equations, we can show that π_f and w_f are increasing with firm productivity, while c is falling in firm productivity. Moreover, due of lower marginal costs, more productive firms set lower prices allowing them to achieve higher markups, and produce more[16].

The firms in sector X set prices to maximize profits $\Pi = pq - (\tilde{w}_L N_L + \tilde{w}_H N_H) - f_o$. It is not possible to solve for prices explicitly in this model. The following function implicitly defines a firm's optimal price (p) as:

$$D(p,.) = -\frac{L}{\gamma}p + q + \frac{L}{\gamma}c - q\frac{\tilde{\eta}}{1+\tilde{\eta}} \tag{3.12}$$

---

[13]For firms that do not offshore $\bar{z}_f$ is zero.

[14]Note that in equilibrium $N_f = \frac{q}{\phi} a_f$

[15]I assume that the search cost is sunk at the time of firm's optimization decisions and hence does not affect the operating profit or the marginal cost. Altering this assumption gives qualitatively similar results to those obtained here.

[16]Proofs are provided in appendix B.2

where q is determined by equation 3.5 and c is defined by equation 3.11 above. This implicit function will be crucial in determining how prices and other key firm-level variables respond to a shock to offshoring costs. Finally, from equation 3.12, we can solve for the profit maximizing level of output for a firm as:

$$q = \frac{L}{\gamma}(1+\tilde{\eta})(p-c) \tag{3.13}$$

3.3.2 Equilibrium under Limited Offshoring

In sector X firm entry and exit patterns follow the Melitz (2003) model. Firms are identical prior to entry and must pay a sunk entry cost, f_e, to observe the firm-specific productivity draw from a cumulative distribution $G(\phi)$ with density $g(\phi)$ over the support $[1;\infty)$. $G(\phi)$ is assumed to follow a Pareto distribution given by the following distribution and density functions:

$$G(\phi) = 1 - (\frac{1}{\phi})^k \,,\; g(\phi) = \frac{k}{\phi}(\frac{1}{\phi})^k \tag{3.14}$$

Having defined the cutoff productivity for entry $\bar{\phi}$, the ex-post distribution of productivities of firms in sector X can be defined as:

$$\varphi(\phi) = \begin{cases} \dfrac{g(\phi)}{1-G(\bar{\phi})} = \dfrac{k}{\phi}(\dfrac{\bar{\phi}}{\phi})^k & \text{if}\, \phi \geq \bar{\phi} \\ 0 \quad \text{otherwise} & \end{cases} \tag{3.15}$$

Next the average productivity in the sector, $\tilde{\phi}$ is defined as:

$$\bar{z}_f(\tilde{\phi}) = \frac{\int_{\bar{\phi}_o}^{\infty} \bar{z}_f(\phi)d\phi}{M} \tag{3.16}$$

where M is the endogenously determined equilibrium mass of firms in the sector. Hence, $\tilde{\phi}$ is the productivity of the firm that has the average level of offshoring in the sector[17]. This average productivity is relevant for defining the equilibrium in the

[17]Since it is assumed that $\beta t_f(0)w_f^* < w_f$, it follows that if a firm decides to offshore, then it will offshore both types of jobs. Thus $\tilde{\phi}_H = \tilde{\phi}_L = \tilde{\phi}$.

economy. Following Melitz (2003), the equilibrium in sector X is characterized by two conditions. First, the zero-cutoff profit (ZCP) condition asserts that the profits of the marginal entrant should be zero ($\Pi(\bar{\phi}) = 0$). Using this condition, and $\tilde{\phi}$ defined above the average sectoral profits ($\bar{\Pi}$) can be solved for using:

$$\bar{\Pi}(\bar{\phi}) = \Pi(\tilde{\phi}) \qquad \text{ZCP} \tag{3.17}$$

In addition to the ZCP condition, the equilibrium structure in this sector is defined by the free entry condition: expected profits from firm entry in sector X should equal the sunk entry cost (f_e), thereby setting the expected payoffs equal to zero, ex-ante. The FE condition can be written as:

$$\begin{aligned} &[1 - G(\bar{\phi})]\bar{\Pi}(\bar{\phi}) = f_e \\ &\Rightarrow \bar{\Pi}(\bar{\phi}) = (\bar{\phi})^k f_e \qquad \text{FE} \end{aligned} \tag{3.18}$$

Appendix B.5 demonstrates how the ZCP and FE conditions behave in the $(\bar{\Pi}; \bar{\phi})$ space and proves the existence and uniqueness of equilibrium under sufficient conditions. Finally, to balance trade, it is assumed that exports of the numeraire good pay for the aggregate offshoring bill.

3.4 Comparative Statics

3.4.1 Firm's Response to a Fall in the Cost of Offshoring

In this section I examine how firms in sector X respond to an exogenous fall in the marginal costs of offshoring, which occurs through a relaxation in the policy constraint, β. Appendix B.3 shows that as long as a sufficient conditions (see equation B.2 and B.3 — the technological slack conditions), are satisfied, a fall in β increases offshoring of task-f along the intensive margin, since firms will respond by increasing $\bar{z}_f$. The technological slack conditions ensure that firms have not hit their technological constraint, above which offshoring becomes technologically too costly, despite a fall in β. If firms that are already offshoring have offshored much of their activities then we would not expect a fall in β to affect the level of offshoring of tasks at the intensive margin. There will, however, also be a rise in offshoring along the extensive margin, since the fall in the marginal cost of offshoring implies that the new firms will begin offshoring as well (appendix B.4b shows that $\bar{\phi}_o$ falls with β).

To simplify the exposition of the comparative statics, firms can be split up into three categories. The first group consists of firms that are the most productive and that were offshoring before and continue to offshore after the shock. The next group are the new entrants to offshoring. The last category are the firms that do not source from abroad before and after the fall in β. For the first group of firms, a fall in β reduces the cost of previously offshored tasks as well as allows new tasks to be offshored — the marginal tasks. For the second group the entire cost saving comes from the newly offshored tasks, i.e. the marginal tasks since by definition there is no infra-marginal tasks for this group of firms.

The following propositions summarize the firm-level effects from a fall in the policy-related offshoring costs, β.

Proposition 1: ***For new and existing offshorers, a fall in*** β ***reduces prices*** (p) ***and marginal costs*** (c)***, while raising markups*** (μ)***, operating profits per domestic worker of type-f*** (π_f)***, and domestic wages of type-f workers*** (w_f)***.***

A fall in β reduces the costs of continuing offshoring firms along both marginally and inframarginally offshored type-f tasks (productivity effect), allowing these firms to lower prices and move down their linear demand schedule and increase their output. Additionally, since demand becomes more inelastic at lower prices, firms are able to increase their markups, μ, leading to higher operating profits, which are shared with both types of domestic workers, thus raising their wages through a rent sharing effect. For the firms who newly begin offshoring as a result of fall in β, the effects are similar to that of the existing offshoring firms. Appendix B.6 contains the proof of Proposition1.

Proposition 2: ***For the non-offshoring firms, a fall in β reduces the firm's markups (μ), operating profits per domestic worker of type-f (π_f), and domestic wages of type-f workers (w_f).***

Purely domestic firms are negatively affected by a fall in β. The more productive firms who can take advantage of offshoring lower prices thus shifting in the demand schedules of the non-offshoring firms. This causes their markups to fall, which translates into lower operating profits and consequently lower wages of all existing workers at these firms. For these firms the rent sharing effect lowers the wages of all workers. The proofs are provided in Appendix B.7. The above two propositions imply that in terms of wages, existing workers at the offshoring firms gain, whereas those at the non-offshoring ones lose.

Proposition 3: ***For sufficiently small γ, new offshoring opportunities lead to a reallocation of production and both types of labor from the non-offshoring firms towards the new and existing offshorers. For the offshoring firms, the net effect of offshoring on home employment and the share of unskilled labor is ambiguous. However, at non-offshoring firms employment falls but the share of unskilled workers remain unaffected.***

Proposition 1, shows that a fall in β allows the firms that can take advantage of offshoring to reduce prices, thereby increasing their competitiveness compared to non-offshorers. This results in a shift of production towards the former group of firms. The fall in the demand for output for the non-offshoring firms leads to a fall in employment of both types of labor, since production and labor demand are proportional. Since there is no scope for substitution of tasks between the two types of labor, the share of unskilled workers remains unaffected for the firms that never offshore i.e. there is no change in the skill composition. On the other hand, the effect on home employment for the offshoring firms is ambiguous because the employment gain due to increase in production is offset by the loss of jobs due to offshoring. The effect on the share of unskilled workers in the home firm is also ambiguous and depends on which type of tasks is relatively easier to offshore. For example if unskilled tasks are easier to offshore then the share of unskilled workers in the domestic workforce would fall in the offshoring firms.The proofs are provided in appendix B.6f and B.7f.

Proposition 4: ***A fall in β increases the average domestic wage in the offshoring firms due to a rent sharing effect. This effect can be further reinforced or weakened by an accompanying skill composition effect. Average wages in the non-offshoring firms, however, declines due to a rent sharing effect only; there is no skill composition effect for these firms.***

This is the main prediction of the model and follows directly from Propositions 1-3. The proof of the proposition is provided in appendix B.6g and B.7g. The above proposition shows that offshoring affects average wages (in firms that offshore) in two ways: on the one hand, it can increase the wages of all existing workers through a rent sharing effect, if firms share offshoring induced increase in profits with its workers. On the other hand offshoring can also change the workforce composition in the home firm, thus affecting average wages through a skill composition effect. In which direction the skill composition works is ambiguous and ultimately an empirical question.

In summary, a fall in offshoring costs allows new and existing offshoring firms to gain a competitive advantage vis-a-vis purely domestic firms. This leads to diverging effects on markups, operating profits per domestic worker, and domestic wages. Furthermore, offshoring potentially can reallocate production and employment from non-offshoring firms to the offshoring ones. Becker and Muendler (2008) find supporting evidence for Germany. Using employer-employee linked data, they find that expanding MNCs retain more jobs than competitors without foreign expansion. Similarly, the empirical analysis of Sethupathy (2008) finds no differential outcomes in employment between offshoring and non-offshoring firms. However the empirical analysis by Fosse and Maitra (2010) using Danish employer-employee data finds that firms that increase offshoring hire at a lower rate compared to those that do not. The paper also finds that offshoring can affect firm level wages by increasing both skill composition and rent sharing effects, especially for firms that continue offshoring.

3.4.2 Sector Level Analysis

To determine the effect of the marginal liberalization we need to examine how the ZCP and the FE conditions are affected due to a fall in the cost of offshoring. While the FE condition remains unchanged, the ZCP condition is affected by offshoring. Appendix B.8 demonstrates that the ZCP curve must shift up in response to increased offshoring that leads to a higher $\bar{\phi}$ and higher $\bar{\Pi}$ in the post-offshoring equilibrium. Let the initial cutoff productivity be denoted as $\bar{\phi}_1$. Then, firms with productivity $\bar{\phi}_1 < \phi < \bar{\phi}_2$, must exit the industry, where $\bar{\phi}_2$ is the new cut-off. This means that the new offshoring opportunity drives out less productive firms.

Let us look at how the sector-level variables respond to increased offshoring. Average prices in sector X, P_x, decrease with offshoring for two reasons. First, prices decrease at the offshoring firms, both new and existing ones. Second, the least productive firms with the highest prices exit. Average productivity also increases since the least productive firms exit the industry following increased offshoring opportunity. The same line of argument implies that, average industry profitability and average wages also increase. The effect of marginal liberalization on employment of type-f worker and the share of unskilled labor in sector X is ambiguous. First we discuss the effect on employment. Employment of both types of workers fall as a result of three effects: contraction of non-offshoring firms, exit of the least productive firms, and offshoring of jobs by new and continuing offshorers. However, the offshoring firms also expand thus increasing the demand for labor. If the expansionary effect offsets the loss of jobs at the less productive firms plus the direct loss of jobs, the net employment effect can be positive. The share of unskilled workers in the sector is affected only through the firms that take advantage of offshoring. If the firms are offshoring unskilled tasks relatively more then the average share of unskilled workers will fall. However, which type of task ends up being offshored more depends on the type of activities, the wages abroad and the technology factor $t_f(z_f)$.

3.5 Conclusion

This paper builds a theory model to investigate the effect of offshoring on firm level average wages, with a focus on the different channels through which wages might be affected. There are two channels: the first is called the skill composition effect and affects the firm level average wage by changing the work-force composition at these firms. The second effect, called the rent sharing effect, works through imperfections in the labor market. A fall in the cost of offshoring, by reducing cost, increases profitability at the firms that take advantage of offshoring. The offshoring induced increased profits can be shared with all workers through bargaining between firms and workers, leading to a higher pay for all existing workers and thus resulting in higher average wages.

Papers studying the effect of offshoring usually focus on one channel shutting down the other. However, it is essential to take into account both effects, since they can potentially work in opposite directions. This paper provides a simple model to analyze both effects simultaneously. The model extends Sethupathy (2008) by introducing heterogeneous labor with the scope for offshoring tasks performed by the different types of labor. The technology associated with offshoring is different for the two types of tasks, though there is a common policy related cost of offshoring. The presence of heterogeneous firms and fixed costs of offshoring implies that only the more productive firms are able to take advantage of offshoring opportunities. Offshoring enables these firms to experience productivity gains, which raises profitability. The offshoring induced higher profits, due to the rent sharing mechanism, gets translated into higher wages for all domestic workers leading to higher average wages in the offshoring firms. Moreover, if one type of task is offshored more than the other that would change the domestic composition of workers in the firm and affect its average wage. For example, if firms are offshoring low-paid, low-skilled jobs then average domestic wages would automatically increase with offshoring. The interaction of the rent sharing effect and the skill composition effect would determine how average wages are affected following an increase in offshoring. The main prediction of the model is that a fall in the cost of offshoring increases average wage in the offshoring firm due to a rent sharing effect. This effect can be further reinforced or weakened by an accompanying skill composition effect. Average wages in the non-offshoring firms declines due to a rent sharing effect only; there is no skill composition effect for these firms in the model. The empirical paper by Fosse and Maitra (2010), using Danish employer-employee data, supports the predictions of this model. They show that both rent sharing and skill composition effects are important for explaining the wage effects of offshoring.

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Appendix A

Appendix for Chapter 1

A.1 Merging Firm Level Data with the Transactions Level Customs Data

We use phone number and zip code to merge the two datasets, following Yu (2011). The phone numbers in the product level trade data include area phone codes and a hyphen, whereas those in the firm-level production data do not. Therefore, we use the last seven digits of the phone number to serve a proxy for firm identification.

A.2 Construction of TFP (Olley-Pakes)

Here we describe in details the Olley-Pakes approach to estimating firm's TFP with some extensions. First, we adopt different price deflators for inputs and outputs. Data on input deflators and output deflators are from Brandt et al. (2011) in which the output deflators are constructed using reference price information from China's Statistical Yearbooks whereas input deflators are constructed based on output deflators and China's national input-output table (2002).

Next, we construct the real investment variable using the perpetual inventory method. Rather than assigning an arbitrary number for the depreciation ratio, we use the firm's real depreciation rate provided by the Chinese firm-level dataset.

We work with the standard Cobb-Douglas production function:

$$Y_{it} = \pi_{it} M_{it}^{\beta_m} K_{it}^{\beta_k} L_{it}^{\beta_l} \tag{A.1}$$

Where Y_{it} is the output of firm i in year t, K_{it}, L_{it} and M_{it} denotes labor, capital, and intermediate inputs, respectively. By assuming that the expectation of future realization of the unobserved productivity shock, v_{it}, relies on its contemporaneous value, the firm i's investment is modeled as an increasing function of both unobserved productivity and log capital, $k_{it} = log(K_{it})$. Following previous works, such as van Biesebroeck (2005) and Amiti and Konings (2007), we add the firm's export decision as an extra argument of the investment function since most firms' export decisions are determined in the previous period (Tybout, 2003):

$$I_{it} = \tilde{I}(k_{it}, v_{it}, X_{it}) \tag{A.2}$$

where X_{it} is a dummy to measure whether firm i exports in year t. Therefore, the inverse function of I_{it} is:

$$v_{it} = \tilde{I}^{-1}(k_{it}, I_{it}, X_{it}) \tag{A.3}$$

The unobserved productivity also depends on log capital and the firm's export decisions. Accordingly, the estimation specification can now be written as:

$$y_{it} = \beta_0 + \beta_m m_{it} + \beta_l l_{it} + g(k_{it}, I_{it}, X_{it}) + \epsilon_{it} \tag{A.4}$$

where $g(k_{it}, I_{it}, X_{it})$ is defined as $\beta_k k_{it} + \tilde{I}^{-1}(k_{it}, I_{it}, X_{it})$. Following Olley and Pakes (1996) and Amiti and Konings (2007), fourth-order polynomials are used in log-capital, log-investment and firm's export dummy to approximate g(.). In addition, we also include a WTO dummy (i.e., one for a year after 2001 and zero for before) to characterize the function g(.) as follows:

$$g(k_{it},\, I_{it},\, X_{it},\, WTO_t) = (1 + WTO_t + X_{it}) \sum_{r=0}^{4} \sum_{s=0}^{4} \delta_{rs} k_{rs}^{r} I_{rs}^{s} \tag{A.5}$$

After finding the estimated coefficients β_m and β_l, we calculate the residual R_{it} which is defined as:

$$R_{it} = lnY_{it} - \hat{\beta}_m lnM_{it} - \hat{\beta}_l lnL_{it}$$

The next step is to obtain an unbiased estimated coefficient of $\hat{\beta}_k$. We assume firm's productivity follows a exogenous Markov process, $v_{it} = h(v_{it-1}) + \eta_{it}$. To correct the selection bias due to firm exit, Amiti and Konings (2007) suggested estimating the probability of a survival indicator on a high-order polynomial in log-capital and log-investment. One can then accurately estimate the following specification:

$$R_{it} = \beta_k lnK_{it} + h(\hat{g}_{it-1} - \beta_k lnK_{i,t-1},\, \hat{pr}_{i,t-1}) + \epsilon_{it}^{*} \tag{A.6}$$

where $\hat{pr}_{i,t-1}$ denotes the fitted value for the probability of the firm's exit in the next year, and $\epsilon_{it}^{*} = \epsilon_{it} + \eta_{it}$ denotes the composite error. Since the specific true functional form of the inverse function h is unknown, it is appropriate to use fourth-order polynomials in g_{it-1} and $k_{i,t-1}$ to approximate that. In addition, A.6 also requires the estimated coefficients of the log-capital in the first and second term to be identical. Therefore, non-linear least squares is used (Pavcnik, 2002; Arnold, 2005). Finally, the Olley-Pakes type of TFP for each firm i in industry j is obtained once the once the estimated coefficient $\hat{\beta}_k$ is obtained:

$$TFP_{it}^{OP} = lnY_{it} - \hat{\beta}_m lnM_{it} - \hat{\beta}_k lnK_{it} - \hat{\beta}_l lnL_{it} \tag{A.7}$$

A.3 Replicating counter-Melitz Finding in the Merged Data

Table A.1: Exporters productivity vs. ownership

Dependent variables

	Value Added per worker			TFP (Olley Pakes)		
	All Firms	FIE	non-FIE	All Firms	FIE	non-FIE
exporters	0.183*	-0.036*	0.208*	0.146*	-0.003	0.201*
	(0.008)	(0.012)	(0.011)	(0.007)	(0.011)	(0.010)
N	427849	72630	355219	446020	74764	371256
R-squared	0.196	0.236	0.211	0.338	0.338	0.343

Note: The above table reports regressions of the dependent variable on exporter dummy, omitted group is non-exporter. All regressions include industry, province and year fixed effects and labor as additional controls. Robust standard errors in parentheses clustered at the firm level.* $p<0.01$, † $p<0.05$, ††$p<0.1$.

Table A.2: Exporter productivity vs. capital intensity

(a) Using Value-Added per Worker as Dependant Variable

	Labor intensive	Medium	Capital intensive
exporter	-0.189*	-0.118*	0.049†
	(0.012)	(0.012)	(0.022)
Observations	110940	189700	127209
R-squared	0.137	0.132	0.155

Note: The above tables report regressions of the dependent variable on exporter dummy, omitted group is non-exporter. All regressions include industry, province and year fixed effects as additional controls. Regressions are run by capital intensity of the sectors. Robust standard errors in parentheses clustered at the firm level.* p<0.01, † p<0.05, ††p<0.1.

(b) Using Value-Added per Worker as Dependant Variable and Controlling for Size

	Labor intensive	Medium	Capital intensive
exporter	0.015	0.088*	0.180*
	(0.012)	(0.013)	(0.022)
Observations	110940	189700	127209
R-squared	0.204	0.182	0.181

Note: The above tables report regressions of the dependent variable on exporter dummy, omitted group is non-exporter. All regressions include industry, province and year fixed effects and firm size as additional controls. Regressions are run by capital intensity of the sectors. Robust standard errors in parentheses clustered at the firm level.* p<0.01, † p<0.05, ††p<0.1.

(c) Using TFP (Olley-Pakes) as Dependant Variable

	Labor intensive	Medium	Capital intensive
exporter	0.051*	0.126*	0.261*
	(0.011)	(0.011)	(0.02)
Observations	116120	197066	132834
R-squared	0.254	0.371	0.294

Note: The above tables report regressions of the dependent variable on exporter dummy, omitted group is non-exporter. All regressions include industry, province and year fixed effects as additional controls. Regressions are run by capital intensity of the sectors. Robust standard errors in parentheses clustered at the firm level.* p<0.01, † p<0.05, ††p<0.1.

Appendix B

Appendix for Chapter 3

B.1 Solution to the Bargaining Game

In order to solve equation 3.2, we first solve the firm's profit maximization exercise in the second stage product market competition and work backwards.

The firm's profit maximization problem can be written as:

$$Max_p \, pq(p) - c(q(p), w_L, w_H, .) \tag{B.1}$$

Where cost $c(q(p), w_L, w_H, .) = w_L N_L^d + w_H N_H^d + \beta T_L(\bar{z}_L) w_L^* + \beta T_H(\bar{z}_H) w_H^*$ and $T_f(\bar{z}_f) = \int_0^{\bar{z}_f} t_f(\bar{z}_f)$. It follows: $\frac{\partial c(q(p), w_L, w_H, .)}{\partial w_f} = N_f^d$. From equation B.1, using the envelope theorem we can show that $\frac{d\Pi}{dw_f} = -N_f^d$. This condition is used to solve for equation 3.2 yielding equation 3.3. Check the solution for the right-to-manage model in Abowd and Lemieux (1993) and Estevao and Tevlin (2003) for details.

B.2 Comparative Statics with Respect to Productivity

This section provides proofs of how the firm level variables behave with firm productivity. We show that (a) $\frac{dp}{d\phi} < 0$; (b) $\frac{dc}{d\phi} < 0$; (c) $\frac{d\mu}{d\phi} > 0$; (d) $\frac{dq}{d\phi} > 0$; (e) $\frac{d\Pi}{d\phi} > 0$; (f) $\frac{d\pi_f}{d\phi} > 0$; (g) $\frac{dw_f}{d\phi} > 0$. For expositional simplicity we assume $\bar{z}_f = 0$ in the derivations.

(a) To show $\frac{dp}{d\phi} < 0$:

We begin by using the $D(p, \phi, .)$ function given by equation 3.12 that implicitly solves for the optimal profit for the firm. Now, using the implicit function theorem it follows that $\frac{dp}{d\phi} = -\frac{\frac{\partial D}{\partial \phi}}{\frac{\partial D}{\partial p}}$:

$$\frac{\partial D}{\partial \phi} = -\frac{L\bar{w}_y(a_L + a_H)}{(\phi)^2\gamma(1+\tilde{\eta})} < 0$$

$$\frac{\partial D}{\partial p} = -\frac{2L}{\gamma(1+\tilde{\eta})} < 0$$

$$\frac{dp}{d\phi} = -\frac{\bar{w}_y(a_L + a_H)}{2(\phi)^2} < 0$$

Thus prices are lower at more productive firms.

(b) To show $\frac{dc}{d\phi} < 0$:

Using equation 3.11 and then taking derivative with respect to ϕ and substituting in for $\frac{dp}{d\phi}$ from part (a) gives:

$$\frac{dc}{d\phi} = -\frac{\bar{w}_y(a_L + a_H)(2+\tilde{\eta})}{2(\phi)^2(1+\tilde{\eta})} < 0$$

Thus marginal costs are also lower at more productive firms.

(c) To show $\frac{d\mu}{d\phi} > 0$:

$$\frac{d\mu}{d\phi} = \frac{dp}{d\phi} - \frac{dc}{d\phi} > 0$$

The inequality follows from (a) and (b) since $\frac{dp}{d\phi} < \frac{dc}{d\phi}$, indicating that markups are higher at more productive firms.

(d) To show $\frac{d\Pi}{d\phi} > 0$:

$\Pi = q\mu$. So $\frac{d\Pi}{d\phi} = q\frac{d\mu}{d\phi} + \mu\frac{dq}{d\phi} > 0$ since $\frac{d\mu}{d\phi} > 0$ and $\frac{dq}{d\phi} > 0$. Thus aggregate operating profits is increasing in firm productivity.

(e) To show $\frac{d\pi_f}{d\phi} > 0$:

Using equation 3.9 and then taking derivative with respect to ϕ and substituting in for $\frac{dp}{d\phi}$ from part (a) gives:

$$\frac{d\pi_f}{d\phi} = \frac{2p\phi - \bar{w}_y(a_L + a_H)}{2\phi a_f(1+\tilde{\eta})} > 0$$

To see why the numerator in the above expression must be positive, set $\bar{z}_f = 0$ in equation 3.9, to get the equilibrium solution for π_f for purely domestic firms. Since π_f must be positive in equilibrium, the expression $p\phi - \bar{w}_y(a_L + a_H)$ must be positive and so the numerator of the expression above must also be positive.

(f) To show $\frac{dw_f}{d\phi} > 0$:

Taking the derivative of equation 3.3 with respect to ϕ and using the result from part (e) gives:

$$\frac{dw_f}{d\phi} = \eta_f \frac{d\pi_f}{d\phi} > 0$$

(g) To show $\frac{dq}{d\phi} > 0$:

Taking the derivative of equation 3.6 with respect to ϕ and again plugging in for $\frac{dp}{d\phi}$ from part (a) gives:

$$\frac{dq}{d\phi} = -\frac{L}{\gamma}\frac{dp}{d\phi} = \frac{L}{\gamma}\frac{\bar{w}_y(a_L + a_H)}{2(\phi)^2} > 0$$

B.3 Comparative Statics for the Task Cut-offs

(a) To show that $\frac{d\bar{z}_f}{d\beta} > 0$, i.e. a fall in cost of offshoring leads to higher offshoring we use equation 3.8 to implicitly define the cut-offs $(\bar{z}_L, \bar{z}_H)$ as: $\beta t_L(\bar{z}_L)w_L^* = w_L$ for low-skilled jobs and $\beta t_H(\bar{z}_H)w_H^* = w_H$ for high-skilled ones. For simplicity we show the two extreme cases[1], first we assume that there is no offshoring in high-

[1] The two extreme cases are shown here for expositional ease, qualitatively similar results can be obtained without the assumption of only one type of task being offshored.

skilled jobs i.e. $\bar{z}_H = 0$. Substituting equation 3.10 for w_L, gives the following implicit function for the productivity cut-off for low-skilled tasks:

$$F_L(\bar{z}_L, \beta) = \beta t_L(\bar{z}_L)(1-\bar{z}_L)w_L^* a_L(1+\tilde{\eta}) - p\phi\eta_L + \beta\bar{t}_L(\bar{z}_L)w_L^* a_L\eta_L - \bar{w}_y[(1+\eta_H)(1-\bar{z}_L)a_L - a_H\eta_L] = 0$$

Using the implicit function theorem we can derive $\frac{d\bar{z}_L}{d\beta} = -\frac{\frac{\partial F_L}{\partial \beta}}{\frac{\partial F_L}{\partial \bar{z}_L}}$. Where

$$\frac{\partial F_L}{\partial \beta} = t_L(\bar{z}_L)(1-\bar{z}_L)w_L^* a_L(1+\tilde{\eta}) + \bar{t}_L(\bar{z}_L)w_L^* a_L\eta_L > 0$$

$$\frac{\partial F_L}{\partial \bar{z}_L} = [\beta t_L^{'}(\bar{z}_L)(1-\bar{z}_L)w_L^* a_L - \beta t_L(\bar{z}_L)w_L^* a_L](1+\tilde{\eta}) + \beta\bar{t}_L^{'}(\bar{z}_L)w_L^* a_L\eta_L + \bar{w}_y(1+\eta_H)a_L$$

Note, that if $\frac{\partial F_L}{\partial \bar{z}_L} > 0$ is satisfied, which is called the first technological slack condition, then $\frac{d\bar{z}_L}{d\beta} < 0$. The condition is:

$$[\beta t_L^{'}(\bar{z}_L)(1-\bar{z}_L)w_L^* a_L - \beta t_L(\bar{z}_L)w_L^* a_L](1+\tilde{\eta}) + \beta\bar{t}_L^{'}(\bar{z}_L)w_L^* a_L\eta_L + \bar{w}_y(1+\eta_H)a_L > 0 \tag{B.2}$$

Similarly, to show $\frac{d\bar{z}_H}{d\beta} < 0$, we assume $\bar{z}_L = 0$ and use the implicit function for the productivity cut-off for high-skilled tasks:

$$F_H = \beta t_H(\bar{z}_H)(1-\bar{z}_H)w_H^* a_H(1+\tilde{\eta}) - p\phi\eta_H + \beta\bar{t}_H(\bar{z}_H)w_H^* a_H\eta_H - \bar{w}_y[(1+\eta_L)(1-\bar{z}_H)a_H - a_L\eta_H] = 0$$

Using the implicit function theorem we can derive $\frac{d\bar{z}_H}{d\beta} = -\frac{\frac{\partial F_H}{\partial \beta}}{\frac{\partial F_H}{\partial \bar{z}_H}}$. Where

$$\frac{\partial F_H}{\partial \beta} = t_H(\bar{z}_H)(1-\bar{z}_H)w_H^* a_H(1+\tilde{\eta}) + \bar{t}_H(\bar{z}_H)w_H^* a_H\eta_H > 0$$

$$\frac{\partial F_H}{\partial \bar{z}_H} = \beta t_H^{'}(\bar{z}_H)(1-\bar{z}_H)w_H^* a_H(1+\tilde{\eta}) - \beta t_H(\bar{z}_H)w_H^* a_H(1+\tilde{\eta}) + \beta\bar{t}_H^{'}(\bar{z}_H)w_H^* a_H\eta_H + \bar{w}_y(1+\eta_L)a_H$$

Note, that if $\frac{\partial F_H}{\partial \bar{z}_H} > 0$ is satisfied, which is called the second technological slack condition, then $\frac{d\bar{z}_H}{d\beta} < 0$. The condition is:

$$[\beta t_H^{'}(\bar{z}_H)(1-\bar{z}_H)w_H^* a_H - \beta t_H(\bar{z}_H)w_H^* a_H](1+\tilde{\eta}) + \beta\bar{t}_H^{'}(\bar{z}_H)w_H^* a_H\eta_H + \bar{w}_y(1+\eta_L)a_H > 0 \tag{B.3}$$

As long as the technological slack conditions hold, a fall in β increases offshoring of both types of tasks by firms that were already offshorers. This happens if the technological cost $t_f(.)$ does not increase too steeply with tasks or if cost savings are large because of high $\bar{w}_y$, or low β, or low w_f^*.

(b) To show $\frac{d\bar{z}_f}{d\phi} > 0$ i.e. offshoring of type-f task is increasing in productivity. Again, for simplicity we show the two extreme cases, first we assume that there is no offshoring in high-skilled jobs i.e. $\bar{z}_H = 0$ and show $\frac{d\bar{z}_L}{d\phi} > 0$. From the implicit function theorem it follows that $\frac{d\bar{z}_L}{d\phi} = -\frac{\frac{\partial F_L}{\partial \phi}}{\frac{\partial F_L}{\partial \bar{z}_L}}$.

$$\frac{\partial F_L}{\partial \phi} = -p\eta_L - \phi\eta_L \frac{dp}{d\phi} = -\eta_L \frac{2p\phi - \bar{w}_y(a_L + a_H)}{2\phi} < 0$$

The sign follows from the same logic as in appendix B.2f. $\frac{\partial F_L}{\partial \bar{z}_L} > 0$ from the technological slack condition given in equation B.2. Hence it follows that as long as the first technological slack condition holds we can show $\frac{d\bar{z}_L}{d\phi} > 0$.

Next to show $\frac{d\bar{z}_H}{d\phi} > 0$ we assume that there is no offshoring in low-skilled jobs i.e. $\bar{z}_L = 0$. From the implicit function theorem it follows that $\frac{d\bar{z}_H}{d\phi} = -\frac{\frac{\partial F_H}{\partial \phi}}{\frac{\partial F_H}{\partial \bar{z}_H}}$.

$$\frac{\partial F_H}{\partial \phi} = -p\eta_H - \phi\eta_H \frac{dp}{d\phi} = -\eta_H \frac{2p\phi - \bar{w}_y(a_L + a_H)}{2\phi} < 0$$

Again, the sign follows from the same logic as in appendix B.2f. Note that $\frac{\partial F_H}{\partial \bar{z}_H} > 0$ from the technological slack condition given in equation B.3. Hence it follows that as long as the second technological slack condition holds we can show $\frac{d\bar{z}_H}{d\phi} > 0$.

B.4 Existence of Productivity Cut-offs

(a) Prove existence of $\bar{\phi}_o$:

The exposition is similar to the one provided in Sethupathy (2008). The sunk costs of offshoring, f_o, pin down a productivity cut-off, $\bar{\phi}_o$, such that firms with $\phi > \bar{\phi}_o$ are able to offshore and firms with $\phi < \bar{\phi}_o$ are unable to offshore. Thus, if this cut-off exists then there is a firm at the margin who is indifferent between offshoring and not offshoring. To show such a cut-off exists, we begin by noting that offshoring, by saving on wages, allows a firm to lower its marginal costs, c, and become more efficient. Hence, for any firm with productivity ϕ, $c_o(\phi) < c(\phi)$, where $c_o(\phi)$ represents the firm's marginal costs with offshoring, and $c(\phi)$ represents the firm's marginal costs with no offshoring. Define ϕ_1 such that $c(\phi_1) = c_o(\phi)$. We also know that

$c(\phi_1) < c(\phi)$ and using the proof from appendix B.2b, we can conclude that $\phi_1 > \phi$. Hence offshoring by reducing costs make the firm effectively more productive. From appendix B.2d, we know that firms with higher productivity achieve higher profits. So we can define $\bar{\phi}_o$ as the productivity level at which firm is indifferent between offshoring and becoming more efficient and not offshoring:

$$\Pi(\phi_1(\bar{\phi}_o)) - f_o = \Pi(\bar{\phi}_o) \tag{B.4}$$

(b) A marginal liberalization increases offshoring:

A fall in β provides an even greater efficiency boost from offshoring, which is proved in appendix B.6. Hence, the original marginal firm is making positive profits in the new equilibrium after a fall in β. For any given ϕ, $\phi_1(\bar{\phi}_o)$ is higher than before. Then, for the equality in equation B.4 to hold, $\bar{\phi}_o$ must fall allowing for new offshoring opportunities.

B.5 Proving Existence and Uniqueness of Equilibrium

I begin by deriving the behavior of the FE curve in the $(\bar{\Pi};\bar{\phi})$ space. The FE condition is given by:

$$\bar{\Pi}(\bar{\phi}) = (\bar{\phi})^k f_e$$

The first derivative is given by :

$$\bar{\Pi}'(\bar{\phi}) = k(\bar{\phi})^{(k-1)} f_e > 0$$

The second derivative is :

$$\bar{\Pi}''(\bar{\phi}) = k(k-1)(\bar{\phi})^{(k-2)} f_e > 0$$

Hence, the FE curve is upward sloping and convex in the $(\bar{\Pi};\bar{\phi})$ space as long as $(k > 1)$.

In order to analyze the ZCP condition recall equation 3.17 can be written as:

$$\bar{\Pi} = \Pi(\tilde{\phi}) = q(\tilde{\phi})\mu(\tilde{\phi}) - f_o$$

Plugging in equation 3.13, which gives the profit maximizing level of output, in the above condition we get:

$$\bar{\Pi} = \Pi(\tilde{\phi}) = \frac{L}{\gamma}[\mu(\tilde{\phi})]^2(1+\tilde{\eta}) - f_o$$

$$\frac{d\Pi(\tilde{\phi})}{d\tilde{\phi}} = 2\frac{L}{\gamma}[\mu(\tilde{\phi})]\frac{d\mu(\tilde{\phi})}{d\tilde{\phi}}(1+\tilde{\eta}) > 0$$

The above inequality follows from appendix B.2c which shows $\frac{d\mu}{d\phi} > 0$. Next, we can show that $\frac{d\tilde{\phi}}{d\bar{\phi}} > 0$ by examining equation 3.16. First, by definition, the number of active firms, M, falls as $\bar{\phi}$ rises. Also, the total amount of offshoring (the numerator of equation 3.16) increases with $\bar{\phi}$ because as $\bar{\phi}$ rises, there is less competition and marginal non-offshoring firms decide to offshore i.e. $\bar{\phi}_o$ falls. From the above discussion it follows:

$$\frac{d\bar{\Pi}}{d\bar{\phi}} = \frac{d\Pi(\tilde{\phi})}{d\tilde{\phi}}\frac{d\tilde{\phi}}{d\bar{\phi}} > 0$$

Hence, both the FE and the ZCP curves are increasing in the $(\bar{\Pi};\bar{\phi})$ space. To prove the existence and uniqueness of equilibrium we look at the curvature of ZCP with respect to $\bar{\phi}$.

$$\frac{d^2\bar{\Pi}}{d\bar{\phi}^2} = \frac{d^2\Pi(\tilde{\phi})}{d\tilde{\phi}^2}\left(\frac{d\tilde{\phi}}{d\bar{\phi}}\right)^2 + \frac{d\Pi(\tilde{\phi})}{d\tilde{\phi}}\frac{d^2\tilde{\phi}}{d\bar{\phi}^2} \tag{B.5}$$

Now,

$$\frac{d^2\Pi(\tilde{\phi})}{d\tilde{\phi}^2} = 2\frac{L}{\gamma}\left[\left(\frac{d\mu(\tilde{\phi})}{d\tilde{\phi}}\right)^2 + \mu(\tilde{\phi})\frac{d^2\mu(\tilde{\phi})}{d\tilde{\phi}^2}\right](1+\tilde{\eta}) > 0$$

Using the results from appendix B.2a and B.2b, we get that for sufficiently small $\bar{w}_y$, the above second derivative is negative. Next, to sign $\tilde{\phi}''(\bar{\phi})$ let us assume that there is a continuous, one-to-one relationship between $\tilde{\phi}$ and $\bar{\phi}$, define the inverse function $\bar{\phi}(\tilde{\phi})$, and the distribution of $\tilde{\phi}$ as $\upsilon(\tilde{\phi})$. Then, we can find the distribution of $\tilde{\phi}$ in the following way:

$$\upsilon(\tilde{\phi}) = \varphi[\bar{\phi}(\tilde{\phi})]\bar{\phi}'(\tilde{\phi})$$

Following the logic in Sethupathy (2008), as long as the distribution of $\tilde{\phi}$ is sufficiently downward sloping, we get that $\bar{\phi}''(\tilde{\phi}) < 0$. Note that $\tilde{\phi}$ has a pareto distribution, and the sufficient condition requires that the shape parameter for $\upsilon(\tilde{\phi})$ is greater than or equal to the shape parameter for $\varphi(\bar{\phi})$. Finally, since there is a one-to-one mapping between $\tilde{\phi}$ and $\bar{\phi}$, we can conclude that $\tilde{\phi}''(\bar{\phi}) < 0$. Under these sufficient conditions we can show that equation B.5, $\frac{d^2\bar{\Pi}}{d\bar{\phi}^2} < 0$. This implies that the ZCP condition is increasing but decelerating in the $(\bar{\Pi}; \bar{\phi})$ space. On the other hand, the FE condition is increasing and accelerating. The final step to confirm the uniqueness and existence of an equilibrium requires that the FE condition at $(\phi_{min} = 1)$ must be below the ZCP at $(\phi_{min} = 1)$, i.e. FE cuts ZCP from below, which can be satisfied if $f_e; \gamma$ are small enough or L is large enough.

B.6 How a Fall in β Affects the Offshoring Firms

This section provides proofs of how the firm level variables behave with fall in the cost of offshoring for firms that are continuing or newly begun offshoring. We show that (a) $\frac{dp^O}{d\beta} > 0$; (b) $\frac{dc^O}{d\beta} > 0$; (c) $\frac{d\mu^O}{d\beta} < 0$; (d) $\frac{d\pi^O_f}{d\beta} < 0$; (e) $\frac{dw^O_f}{d\beta} < 0$; (f) $\frac{dq^O}{d\beta} < 0$.

We begin by defining the cost savings (CS) from a fall in β as the partial of equation 3.11 with respect to β as:

$$CS = \{\bar{t}_L(\bar{z}_L)w^*_L a_L + \bar{t}_H(\bar{z}_H)w^*_H a_H\} + \{\frac{d\bar{z}_L}{d\beta}[\beta\bar{t}'_L(\bar{z}_L)w^*_L a_L - \bar{w}_y a_L] + \frac{d\bar{z}_H}{d\beta}[\beta\bar{t}'_H(\bar{z}_H)w^*_H a_H - \bar{w}_y a_H]\}$$

The terms in the first parenthesis captures the savings due to fall in β that accrue to tasks that were already offshored. The two terms in the second parenthesis captures the savings on new marginal tasks that are offshored due to the fall in β. The second term must be non-negative. If the technological wall has been hit, then $\frac{d\bar{z}_f}{d\beta} = 0$ and the second term disappears. If not, then by appendix B.3a, $\frac{d\bar{z}_f}{d\beta} < 0$ and the whole term becomes positive. Hence, we can definitely sign CS as positive.

(a) To show $\frac{dp^O}{d\beta} > 0$:

We recall that the $D(p^O, \beta, .)$ function (equation 3.12) implicitly solves for the optimal profit for the firm. Now, using the implicit function theorem it follows that $\frac{dp^O}{d\beta} = -\frac{\frac{\partial D}{\partial \beta}}{\frac{\partial D}{\partial p}}$:

$$\frac{\partial D}{\partial \beta} = \frac{L}{\gamma} CS + \frac{\partial q^O}{\partial \beta} \frac{1}{(1+\tilde{\eta})} > 0$$

$$\frac{\partial D}{\partial p^O} = -\frac{2L}{\gamma(1+\tilde{\eta})} < 0$$

$$\frac{dp^O}{d\beta} = \frac{CS}{2\phi} > 0$$

Now, $\frac{\partial q^O}{\partial \beta} > 0$ captures the partial effect of the demand curve shifting in for all firms as the price level falls in sector X and can be seen by examining equation 3.6. To simplify the exposition, for the rest of this proof, I assume that $\frac{\partial q^O}{\partial \beta}$ is small relative to the first expression in $\frac{\partial D}{\partial \beta}$ and thus drop it.

(b) To show $\frac{dc^O}{d\beta} > 0$:

Using equation 3.11 and then taking the derivative with respect to β and substituting in for $\frac{dp^O}{d\beta}$ from part (a) gives:

$$\frac{dc^O}{d\beta} = \frac{CS(2+\tilde{\eta})}{2\phi(1+\tilde{\eta})} > 0$$

Thus marginal costs falls as β falls.

(c) To show $\frac{d\mu^O}{d\beta} < 0$:

It follows from (a) and (b) that $\frac{dp^O}{d\beta} < \frac{dc^O}{d\beta}$ indicating that markups increase as the cost of offshoring falls.

(d) To show $\frac{d\pi_f^O}{d\phi} < 0$:

We first show that $\frac{d\pi_L^O}{d\phi} < 0$. For simplicity we assume that there is no offshoring in high-skilled jobs i.e. $\bar{z}_H = 0$. Now using equation 3.9 and then taking the derivative with respect to β and substituting in for $\frac{dp^O}{d\beta}$ from part (a) gives:

$$\frac{d\pi_L^O}{d\beta} = \frac{\left(-\frac{CS}{2}\right) D + [a_L(1+\tilde{\eta})]\frac{d\bar{z}_L}{d\beta} N}{D^2} < 0$$

where D and N indicate the denominator and numerator, respectively, of the expression in equation 3.9, both of which are positive. Again, knowing that $\frac{d\bar{z}_L}{d\beta} < 0$ from appendix B.3a, we can sign the whole expression above as negative. Using similar logic and assuming $\bar{z}_L = 0$ for simplicity we can show that

$$\frac{d\pi_H^O}{d\beta} = \frac{\left(-\frac{CS}{2}\right) D + [a_L(1+\tilde{\eta})]\frac{d\bar{z}_H}{d\beta} N}{D^2} < 0$$

Thus, operating profits per type-f domestic worker increases as cost of offshoring falls.

(e) To show $\frac{dw_f^O}{d\beta} < 0$:

Taking the derivative of equation 3.3 with respect to β and using the result from part (d) gives:

$$\frac{dw_f^O}{d\beta} = \eta_f \frac{d\pi_f^O}{d\beta} < 0$$

(f) To show $\frac{dq^O}{d\beta} < 0$:

Taking the derivative of equation 3.6 with respect to β and again plugging in for $\frac{dp^O}{d\beta}$ from part (a) gives:

$$\frac{dq^O}{d\beta} = \frac{L}{\gamma}\left[\frac{\lambda M}{\lambda M + \gamma}\frac{d\bar{P}_x}{d\beta} - \frac{dp^O}{d\beta}\right] < 0$$

New entrants and existing offshoring firms lower prices more than non-offshoring firms: compare appendix B.6a with B.7a. Hence, $\frac{d\bar{P}_x}{d\beta} < \frac{dp^O}{d\beta}$ implying that for sufficiently small γ, $\frac{dq^O}{d\beta} < 0$ and production increases with falling offshoring costs. Since employment is a linear function of quantity, it follows that total employment (domestic and foreign) increases with a fall in offshoring costs.

To determine the effect on domestic employment at these firms note that domestic employment can be expressed as:

$$N_f^d = \frac{a_f q(1-\bar{z}_f)}{\phi}$$

While q increases for new and continuing offshorers, we also know that offshoring has increased for these firms (see appendix B.3a) and hence the net effect is ambiguous. Let us consider the extreme case where the high skilled jobs are not offshored i.e. $\bar{z}_H = 0$. In that case $N_H^d = N_H = \frac{a_H q^O}{\phi} > 0$. Thus in the home firm employment of high skilled labor increases but effect on low skilled labor's employment is ambiguous. To understand what happens to the skill ratio in the home firm, note that

$$s_L^O = \frac{N_L^d}{N_L^d + N_H^d} = \frac{a_L(1-\bar{z}_L)}{a_L(1-\bar{z}_L) + a_H(1-\bar{z}_H)}$$

To see how s_L^O (the share of unskilled labor in the firm's domestic workforce) is affected by a fall in the offshoring cost, we again for simplicity look at two extreme cases. First we assume that there is no offshoring in the high skilled sector i.e. $\bar{z}_H = 0$ and can show that $\frac{ds_L^O}{d\beta} > 0$ in this case. Whereas if there is no offshoring in the low-skilled sector i.e. $\bar{z}_L = 0$ we can show that $\frac{ds_L^O}{d\beta} < 0$. Thus sign of $\frac{ds_L^O}{d\beta}$ is ambiguous and depends on which job ends up being offshored relatively more[2].

(g) How the average wage is affected by a fall in the cost of offshoring:

Note that the average wage at the domestic firm can be expressed as

$$w_{avg}^{dom} = s_L^O w_L^O + (1-s_L^O) w_H^O$$

$$\frac{dw_{avg}^{dom}}{d\beta} = \left(s_L^O \frac{dw_L^O}{d\beta} + s_H^O \frac{dw_H^O}{d\beta}\right) + \left(-[w_H^O - w_L^O]\frac{ds_L^O}{d\beta}\right)$$

The first expression in the brackets gives the rent sharing effect, which is positive by appendix B.6e. The second term gives the skill composition effect and its sign is ambiguous since $\frac{ds_L^O}{d\beta}$ is ambiguous. If $\frac{ds_L^O}{d\beta} < 0$, i.e. relatively more unskilled jobs are offshored, so the share of skilled labor in domestic firm increases, then skill composition effect is positive and reinforces the effect of rent sharing on average wages. If

[2]Note, increased opportunity for offshoring increases cost savings and as a result enhances firm productivity. Check Sethupathy(2008) Appendix 7g for details.

$\frac{ds_L^O}{d\beta} > 0$, i.e. relatively more unskilled jobs are offshored, so the share of skilled labor in the domestic firm decreases, then skill composition effect is negative and weakens the effect of rent sharing on average wages.

B.7 How a Fall in β Affects the Non-offshoring Firms

This section provides proofs of how the firm level variables behave with fall in offshoring costs for firms that never offshore. We show that (a) $\frac{dp^D}{d\beta} > 0$; (b) $\frac{dc^D}{d\beta} > 0$; (c) $\frac{d\mu^D}{d\beta} > 0$; (d) $\frac{d\pi_f^D}{d\beta} > 0$; (e) $\frac{dw_f^D}{d\beta} > 0$; (f) $\frac{dq^D}{d\beta} > 0$; (g) $\frac{dw_{avg}^D}{d\beta} > 0$.

(a) To show $\frac{dp^D}{d\beta} > 0$

We recall that the $D(p^D, \beta, .)$ function (equation 3.12) implicitly solves for the optimal profit for the firm. Now, using the implicit function theorem it follows that $\frac{dp^D}{d\beta} = -\frac{\frac{\partial D}{\partial \beta}}{\frac{\partial D}{\partial p}}$:

$$\frac{\partial D}{\partial \beta} = \frac{\partial q^D}{\partial \beta}\frac{1}{(1+\tilde{\eta})} > 0$$

$$\frac{\partial D}{\partial p^D} = -\frac{2L}{\gamma(1+\tilde{\eta})} < 0$$

$$\frac{dp^D}{d\beta} = \frac{2\gamma}{L}\frac{\partial q^D}{\partial \beta} > 0$$

Now, $\frac{\partial q^D}{\partial \beta} > 0$ captures the partial effect of the demand curve shifting in for all firms as the price level falls in sector X and can be seen by examining equation 3.6. The intuition behind this partial effect is that a fall in the marginal cost of offshoring lowers the price level in sector X and hence shifts in the demand curve for purely domestic firms.

(b) To show $\frac{dc^D}{d\beta} > 0$:

Using equation 3.11 and setting $\bar{z}_f = 0$ and then taking the derivative with respect to β gives:

$$\frac{dc^D}{d\beta} = \frac{\tilde{\eta}}{(1+\tilde{\eta})}\frac{dp^D}{d\beta} > 0$$

Thus marginal costs falls as β falls.

(c) To show $\frac{d\mu^D}{d\beta} > 0$:

It follows from (a) and (b) that $\frac{dp^D}{d\beta} > \frac{dc^D}{d\beta}$ indicating that markups fall in the non-offshoring firms as the cost of offshoring falls.

(d) To show $\frac{d\pi_f^D}{d\beta} > 0$:

Using equation 3.9, setting $\bar{z}_f = 0$ and then taking derivative with respect to β gives:

$$\frac{d\pi_f^D}{d\beta} = \frac{\phi \frac{dp^D}{d\beta}}{a_f(1+\tilde{\eta})} > 0$$

Thus, operating profits per type-f domestic worker decreases as cost of offshoring falls.

(e) To show $\frac{dw_f^D}{d\beta} < 0$:

Taking the derivative of equation 3.3 with respect to β and using the result from part (d) gives:

$$\frac{dw_f^D}{d\beta} = \eta_f \frac{d\pi_f^D}{d\beta} > 0$$

(f) To show $\frac{dq^D}{d\beta} > 0$:

Taking the derivative of equation 3.6 with respect to β and again plugging in for $\frac{dp^D}{d\beta}$ from part (a) gives:

$$\frac{dq^D}{d\beta} = \frac{L}{\gamma}\left[\frac{\lambda M}{\lambda M + \gamma}\frac{d\bar{P}_x}{d\beta} - \frac{dp^D}{d\beta}\right] > 0$$

New entrants and existing offshoring firms lower prices more than non-offshoring firms: compare appendix B.6a with B.7a. Hence, $\frac{d\bar{P}_x}{d\beta} > \frac{dp^D}{d\beta}$ implying that for sufficiently small γ, $\frac{dq^D}{d\beta} > 0$ and production decreases with falling offshoring costs. Since employment is a linear function of quantity, it follows that total employment also decreases with a fall in offshoring costs in the non-offshoring firms. The ratio of unskilled worker to skilled worker remains unchanged given that there is no opportunity for substitution between the different types of tasks.

(g) How the average wage is affected by a fall in the cost of offshoring

Note that the average wage for the non-offshoring firm can be expressed as:

$$w_{avg}^D = s_L^D w_L^D + (1 - s_L^D) w_H^D$$

$$\frac{dw_{avg}^D}{d\beta} = \left(s_L^D \frac{dw_L^D}{d\beta} + s_H^D \frac{dw_H^D}{d\beta}\right) > 0$$

The expression in the brackets gives the rent sharing effect, which is positive by appendix B.7e. There is no skill composition effect for the non-offshoring firms since tasks do not allow for substitution. Thus a fall in the cost of offshoring leads to a fall in the average wage at the non-offshoring firms.

B.8 The Post Liberalization Equilibrium in the $(\bar{\Pi}; \bar{\phi})$ Space

To show that the ZCP condition shifts up following liberalization (i.e. $\frac{d\bar{\Pi}}{d\beta} < 0$). From equation 3.17 we get:

$$\frac{d\bar{\Pi}}{d\beta} = \frac{d\bar{\Pi}(\tilde{\phi})}{d\beta}$$

Appendix B.5 gives:

$$\Pi(\tilde{\phi}) = \frac{L}{\gamma}[\mu(\tilde{\phi})]^2(1+\tilde{\eta}) - f_o$$

$$\frac{d\bar{\Pi}(\tilde{\phi})}{d\beta} = 2\frac{L}{\gamma}\mu(\tilde{\phi})\frac{d\mu(\tilde{\phi})}{d\beta}(1+\tilde{\eta}) < 0$$

Note that equation 3.16, represents a firm with average offshoring. Therefore the last inequality follows directly from appendix B.6c, where we found that $\frac{d\mu^O}{d\beta} < 0$. The ZCP curve shifts up following liberalization because the direct effect of offshoring leads to cost savings and increased profitability at the average firm (defined by $\tilde{\phi}$). This is equivalent to higher average industry profits, holding $\bar{\phi}$ constant.