The Impact of Chinese Competition on Mexican Maquiladoras: Evidence from Plant-level Panel Data

Luis Bernardo Torres Ruiz* Hâle Utar‡

First version: August 4, 2009

This Version: August 30, 2009

Abstract

In this paper we analyze the impact of intensified competition from China on Mexican export assembly plants (maquiladoras) using plant-level panel data covering the period from 1990 to 2006. By using the WTO accession of China as a quasi-natural experiment, our difference in difference approach reveals a significant effect of Chinese competition on within plant productivity improvement of maquiladoras. We also find a positive and significant impact of the heightened competition on productivity through entry. Although competition from China also has negative and significant impact on plants' growth, we do not find a major effect on plant exits.

JEL Classification: F14; L25; L60

*University of Colorado, Boulder and Banco de México

†University of Colorado at Boulder

‡The authors would like to thank Gerardo Durand Alcántara, Director of International Trade Statistics, Administrative Registry and Prices for access to the confidential data as well as for helpful information on the data-set. We also thank Wolfgang Keller for his valuable suggestions and comments.

1 Introduction

China's size, rapid economic growth and trade performance is being felt everywhere. Especially so in Mexico which has been a main competitor of China in the United States markets for manufactured products. This competition saw a major shift in favor of China with China's 2001 accession to the World Trade Organization (WTO). By 2003 China had surpassed Mexico as the second most important import supplier to the Unites States, behind Canada.

China's accelerated trade growth due to lower trade costs in the wake of WTO accession provides us with a natural experiment to analyze the impact of international competition in general. Similarity in export baskets between Chinese and Mexican manufacturers to the US market makes the competition between Mexico and China even more intense, and the analysis more revealing.

We explore here what China's export growth means for exporters in Mexico, particularly for the Mexican maquiladoras. Maquiladoras are export assembly plants historically specialized in labor- intensive products such as apparel, footwear, electronics and toys. Long before The North American Free Trade Agreement (NAFTA), favorable duty regulations with the United States have been in place for maquiladoras since 1965. Since then, close proximity to the US market and relatively cheap labor made Mexico one of the most favorable offshoring destination for US companies for a long time. In 2006 the Maquiladora industry in Mexico generated more than 24 billion dollars in foreign exchange, and accounted for 44 percent of total Mexican manufacturing exports.

The impact of China's trade is an important policy question and has recently also received academic attention. Hanson and Robertson (2008) estimate the impact of increase in manufacturing export from China on the demand for export from 10 other developing countries covering the period between 1995-2005. Based on gravity equation estimates they conclude that the impact is small. Bloom et al. (2009) use a panel of establishments from European countries to test the impact of Chinese imports on the use of Information Technology equipment and innovation, finding a positive association between the two.

In this paper, we investigate the impact of the competition from China on Mexican export assembly plants (maquiladoras); on plants' growth, entry, exit and productivity using plant-level panel data that covers the universe of Mexican maquiladoras. The data we use covers the years 1990-2006, a time period long enough that it allows properly identifying the effects, if any, of Chinese competition. Our sample starts in 1990 where China's share in manufacturing trade in the World was 1.74 % and covers until 2006 where China's share became 8.37 % (World Bank).

In contrast to previous studies on the Chinese competition we are better able to isolate the competition effect from the dual, even triple, effects of Chinese trade: China as an export market, China as a partner and China as a competitor. We focus entirely on export assembly plants in Mexico that are tied to the US manufacturing sector where we expect direct competition between Mexican and Chinese plants, also because they have similar export baskets in the US market.

This paper provides a first analysis of any aspect of Mexican Maquiladoras using plant-level panel data. In addition, we examine the link between international competition and productivity using the WTO accession of China as a quasi-natural experiment which allows us to identify the impact of intensified competition on the productivity of Mexican plants.

We find partial evidence supporting the frequently stated view by Mexican policy makers that Chinese competition is forcing maquiladoras to exit low-tech, labor intensive industries and evolve toward higher value added, technology intensive sectors.

We find strong evidence for within plant productivity improvement of maquiladoras due to heightened competition from China. We also find that although the number of entrants decreases with intensified Chinese competition, plants enter with a higher level of productivity as competition intensifies. But we do not find that intensified competition from China improves the productivity of maquiladoras by causing exit of low-productivity plants.

Plant's employment growth is also found to be negatively affected by Chinese competition. More specifically, a one standard deviation increase in China's share of the import penetration rate is found to be associated with a decrease in annual plant employment growth of 6.2 percentage points.

Our results lend support to a commonly held view among Maquiladora managers: "By moving up the technological ladder, companies say they can afford to pay the relatively high salaries common along the Mexican border and not relocate to lower-wage countries." (Lindquist (2004))

Both China and Mexico liberalized their economies since 1980s and hope to gain through increasing openness. Although trade growth was impressive in both countries in the last decades, China's trade growth was also fueled by productivity-based economic growth; whereas Mexico experienced relatively un-impressive economic growth performance. Despite official Mexican concerns regarding China's accession to WTO, our work highlights that long expected productivity growth in Mexico due to export and FDI may have just begun, ironically, triggered by competition from China.

In the next section we describe the environment of maquiladora industry and the data used. In section 3, we sketch some theoretical models. In section 4 our empirical model is outlined, and results are interpreted in section 5 followed by conclusions.

2 Data Overview

2.1 Mexican Maquiladoras

Maquiladora plants are offshoring plants. A typical maquiladora plant imports inputs mostly from the United States, processes them, and then ships them back to the country of origin. The maquiladora program started in the mid-60s; it permits tariff-free transaction of the inputs and the machinery between 'a maquiladora plant' and the foreign companies.[1] Upon the return of the goods, the shipper pays duties only on the value added by manufacture in Mexico (Gruben (2001)).[2]

In general, there are three ways in which a maquiladora can operate: subcontracting, shelter operation and direct ownership. The subcontracting operation offers the least amount of control to the foreign firms, given that the subcontractor fulfills all of the manufacturing operations according to an arrangement established with the foreign firm. Shelter operations offer more control, especially in the production process, but not in the administrative operation of the maquiladora plant, i.e. legal, accounting, customs, etc. Direct ownership offers the foreign firm the most control and supervision over manufacturing operations.

Since its introduction, the maquiladora industry moved from consisting of only low-skilled labor intensive plants, like apparel manufacturing, to more advanced manufacturing processes, like electronics, electrical appliances and automotive. The government allowed the establishment of maquiladoras in the interior regions of Mexico. NAFTA also contributed to maquiladoras being allowed to sell their output domestically. However, this option is rarely exercised.

[1] In order to benefit from the maquiladora program, a plant has to be registered as a maquiladora plant. The bureaucratic steps necessary for registration were simplified significantly with the 1983 reform.

[2] Export Processing Zones (EPZ) are similar to the maquila program of Mexico, and can be found around the world.

The implementation of NAFTA required Mexico to change certain provisions for the maquiladora industry, such as the elimination of certain tariff benefits. Most importantly, on January of 2001, duty-free imports from non-NAFTA countries were eliminated because these countries intended to subsequently re export to another NAFTA country. These changes were based on the rules of origin that were established under the treaty, where goods traded between NAFTA countries are allowed duty free treatment only when the goods satisfy a minimum percentage of North American content. Due to complaints from leaders of the maquiladora industry, the Mexican government revised its regulations of the maquiladora sectors and created a sectoral promotion program to protect the duty-free status of maquiladora imports and therefore, allowing the maquiladora program to continue non-NAFTA content imports. Even after 2001 there is no incentive for a foreign company not to register as being a maquiladora if it is part of a foreign chain of production re-exporting its goods to the US. This is due to the tax provision (APA) that allows maquiladoras not to pay income taxes in the same way as the domestic manufacturing industry (Truett and Truett (2007), Canas and Coronado (2002)).

2.2 Plant-level Data

The maquiladora industry data is from INEGI (Instituto Nacional Estadstica y Geografa). INEGI has conducted an annual survey of the universe of plants registered under the maquiladora program until 2007.[3] The observation unit for the industry is a maquiladora establishment, or plant. The data contains firm id's as well as plant id's so that it is possible to identify

[3]In 2007 a regulatory change was enacted that merges the maquiladora program with an export oriented program for domestic companies known as the Program for Temporary Imports to Promote Exports (PITEX). The new program is called Maquiladora Manufacturing Industry and Export Services (IMMEX). As a result, INEGI stopped reporting maquiladora data after March 2007 and the data has been merged in to the IMMEX data.

multi-plant and single-plant firms. The data set used for the present study is an annual panel data set which covers the period between 1990-2006 for eleven manufacturing maquiladora industries. The survey covers the universe of export assembly plants (maquiladoras) in Mexico. The majority of the plants are owned by US companies. We do not have ownership data at the plant-level due to confidentiality issues, but we do have aggregate capital investment data in maquiladora industry which can be used as an ownership proxy. In 1994, the US share of capital equipment investment was 92.4 %. The next biggest investor was Japan, with a share of 2.5 %. In 2006 the US's share was 88.1 % followed by Canada and Switzerland both having 1.4 % shares (Source: Banco de Mexico). In terms of sales, maquiladoras' export to the US was 99.7 % of the total maquiladora export in 1993. In 2006 94 % of the total maquiladora sales was to the US followed by Canada with a share of 1.7 % (Source: INEGI). INEGI dropped establishments which did not answer the questionnaire or did not report one of the output measures from the data set.[4] Thus, the final data set consist of 27,548 plant year observations that consist of 3,769 plants and 1,455 firms (1655 plants on average per year). For each plant we have information on hours worked and the number of employees by job category, wages paid by job category as well as plant expenditures/inputs, export sales, and value-added. We do not have information on the owned capital, but plants report rental expenditures on different capital items. All the nominal values are expressed in 2002 Mexican peso. See Table 1 for the descriptive statistics. We use separate industry deflators (industry classification for deflators approximately corresponds to 3-digit SICs) for each maquiladora sector to deflate revenues and material expenditures. We use energy deflators to deflate fuel and electricity; a machinery rental deflator to deflate the rental expenditures in machinery and equipment and a building rental deflator to deflate the building rental expenditures. The

[4]Every plant operating under the maquiladora program was legally required to answer the questionnaire. Our data set reveals that plants which did not answer the questionnaire (although legally required) are mostly located in the interior regions of Mexico where maquiladora concentration is very little. Further characterization of non-responsive and removed plants is being pursued in correspondence with INEGI.

deflators are provided by Banco de México.

In the data-set we have 11 sectors, which we match with the corresponding US industries in order to construct our aggregate variables. Table 11 presents these 11 industries and corresponding NAICS codes. The details of the aggregate data construction is given in the appendix.

3 Theoretical Motivation

China and Mexico are the two main offshoring destinations for the US manufacturing sector. We expect that China's recent trade performance accompanied by its accession to WTO has direct and strong effect on Mexican export assembly plants.

3.1 Heckscher-Ohlin Theory

Both China and Mexico have a comparative advantage in labor-intensive products compared to the US. However, China has a comparative advantage in unskilled labor in comparison to Mexico. In 1999, approximately 13 % of the Latin American population has post-secondary education, compared to 3 % in China (Devlin, Estevadeordal and Rodriguez-Clare (2006)). Factor content theory suggests that as trade liberalizes in China, industries that disproportionately employ unskilled workers will shrink in Mexico and the opposite will occur in China. This can happen through the intensive margin, that export assembly plants operating in Mexico shrink. It can also happen through the extensive margin that plant exits occur as a result of the competition and or that heightened competition discourages entry of new plants.

3.2 Product market competition

Product market competition will lead Mexican plants to loose market share in the US market. Typical industrial organization theories with differentiated products (Dixit and Stiglitz (1977), Salop (1977)) predict a negative relationship between competition and innovation/upgrading since competition will decrease the rents of innovating/upgrading for innovators upon innovation.[5] This is the Schumpeterian effect that the incentive to innovate decreases as competition increases. However, the innovation/upgrading decision is also affected by the difference between the pre-innovation and post-innovation rents (Aghion et al. (2005)). If the pre-innovation rent disproportionately decreases due to intensified competition, then firms upgrade or innovate to be able to survive or 'escape' from the competition as much as possible. It is shown in Aghion et al. (2005) that such an escape competition effect is stronger when the market structure is such that technological differences between firms are small. Export assembly industry both in China and Mexico are mostly based on labor-intensive technologies with no large technological gaps between plants, so one may expect to see stronger escape competition effect on plants' incentive to upgrade their technologies.

Another possible channel that can strengthen the escape competition effect is through a parent-subsidiary relationship. Consider two competing offshoring destinations. In response to lower trade costs in one of the offshoring destinations, a parent with a subsidiary in another location would make a 'credible' threat of relocating the subsidiary and therefore increases the incentive for the manager of the subsidiary to put more efforts and decrease X-inefficiencies.

Principal-agent problems are especially relevant to our context as we focus on the performances of subsidiaries. Papers analyze the competition and within firm productivity from a principal-agent problem perspective include Hart (1983), Scharfstein (1988), and Hermalin

[5] Arrow (1962) on the other hand shows that the incentive to do cost-reducing innovation is higher for a perfectly competitive firm than a monopolist in the homogeneous product markets under certain assumptions.

(1992) among others.[6]

One of the paper most relevant to our analysis is Horn et al. (1995). They study the design of an optimal incentive contract for managers and they find that by increasing the product market competition, international competition increases incentives for managers to decrease X-inefficiencies and thereby increases within firm productivity. The specific channel through which their conclusion is derived is the following: Intensified competition increases the demand elasticities that firms face and therefore increases firms' incentive to produce more. As all firms want to expand, this increases demand for labor and increases real wages of production workers. The two effects, higher output and higher production wages, cause managers to supply more effort and use less input from production workers, and thus decrease X-inefficiencies in a world of incomplete contracts with unobservable efforts. We now turn to the empirical model.

4 Empirical Model

Since we are interested in quantifying the impact of competition between China and Mexican Maquiladoras for the US market, we construct our measure of Chinese competition for Maquiladoras as the Chinese share of the import penetration for the matched US industry, following Bernard, Jensen and Schott (2006). That is, our measure of competition is the total Chinese imports coming to the matched US industry relative to consumption of the US industry products:[7]

[6]In Hart (1983) and Scharfstein (1988), competition affects the informational structure and changes the possibilities that principal can make inferences about the manager's action. In Hermalin (1992) competition changes the manager's incentive through the income effect.

[7]An alternative would be the ratio of total imports coming from China to the relevant US industry to total imports in the US industry as used in Bloom et al. (2009). We use both of them. The magnitudes of our results are not the same because of different choices of normalization, but they are qualitatively the same.

$$IMPCH_{jt} = \frac{M_{jt}^{CH}}{M_{jt} + Q_{jt} - X_{jt}} \tag{1}$$

where M_{jt}^{CH} denotes the value of imports of industry j products coming from China to the US at period t. M, Q and X denote total US imports, US production and US exports respectively.

We also use import penetration rate without Chinese imports, defined below, as an aggregate control variable.

$$IMP_{jt} = \frac{M_{jt} - M_{jt}^{CH}}{M_{jt} + Q_{jt} - X_{jt}} \tag{2}$$

4.1 Employment Growth

We start with a basic regression to test the impact of Chinese competition on employment growth in Mexican Maquiladoras. Consider the following specification:

$$\begin{aligned} \Delta lnE_{ijst} = {} & \alpha_0 + \alpha_1 X_{ijst} + \alpha_2 Z_{jt} + \alpha_3 IMPCH_{jt} + \alpha_4 IMPCH_{jt} * x_{ijst} + \\ & \sum_{ts} \delta_{ts}^{YS} Year_t * State_s + \sum_{j} \delta_j^{I} Industry_j + u_i + \epsilon_{ijst} \end{aligned} \tag{3}$$

where $\Delta lnE_{ijst} = lnE_{ijst+1} - lnE_{ijst}$ and E_{ijst} refers to total employment. Subscripts i,j,s, and t index plant, industry, state and year respectively. We allow for unobserved heterogeneity u_i which may be correlated with regressors and estimate equation 3 using OLS. We add interactive state-by-year fixed effects to control for aggregate shocks that may affect employment growth across all sectors but may vary across different states for example due to local labor market conditions. Additionally, we control for industry specific fixed factors that may affect plants' growth. Vector X includes time varying plant-level controls that are found to be important in determining firms' growth: these are size dummies, plant tfp, a multi-plant dummy, and age of a plant.[8] Vector Z includes time varying industry-wide controls; these are industry aggregate variables for the matched US industries that may affect the demand for a particular maquiladora sector: import-penetration rate of the corresponding US industry calculated without the imports from China, the matched US industry hourly wages relative to the corresponding measure in the Maquiladora sector, and the production index of the matched US industries to control for the sector specific business cycles.[9]

We then interact our Chinese competition measure with several variables of interests x_{ijst} (productivity, skill-intensity, capital-intensity); to see if trade between the US and China has a disproportionate effect on any particular type of export-assembly plants in Mexico.

There would be an endogeneity problem if unobserved factors that affect employment growth of maquiladoras also affect the Chinese share of import penetration in the US industry. Our industry level variables including the Chinese share are variables for the US industries not for Maquiladora industries and it is safe enough to assume that the US variables are exogenous from the perspective of Mexican maquiladoras. However, we still did a robustness check by instrumenting the Chinese share of import penetration rate, $IMPCH$, as well as import penetration rate with no Chinese imports, IMP, whenever applicable. We instrumented the Chinese share of import penetration rate with the real exchange rate between China and the US interacted with the 1999 Chinese share of import penetration of the corresponding US NAICS for each Maquiladora sector. Clearly the real exchange rate between China and the US must be exogenous from the perspective of Mexican plants. By interacting it with the cross-sectional shares before China's accession to the WTO, we get the cross-industry variation in the degree of Chinese comparative advantage. Another instrument we use is the

[8] We constructed 5 category of sizes in the ranges 1-50, 51-100, 101-500, 501-1000 and 1000+ dummies as measured by number of employee. We exclude the smallest size category from the regressions.

[9] Details of these data are given in the appendix.

worldwide Chinese imports (exports from China) interacted with the 1999 Chinese import shares over all imports of the corresponding US NAICS for each Maquiladora sector. In order to instrument the import penetration rate calculated without Chinese imports, IMP, we use the industry specific exchange rate for the US industry where the weights for each trading partner's currency are lagged share of imports of that particular trading partner. We also use lagged values of import-penetration rates constructed without Mexican imports as well as Chinese imports. Bloom et al. (2009) use a similar strategy in instrumenting their Chinese competition proxy. In contrast to Bloom et al. (2009), our Chinese competition proxy is not constructed by the imports measure of the same industry reducing endogeneity concerns even further.

4.2 Employment at the Extensive Margin

What happened to the attractiveness of Mexico as an offshoring destination as China started to become a favorable offshoring destination? In order to analyze the impact of Chinese competition on plant entry we aggregate the plant-level data to industry-level and estimate the following equation:

$$ln(ENTRY_{jt} + 1) = \gamma_0 + \gamma_1 Z_{jt} + \gamma_2 IMPCH_{jt} + \sum_t \delta_t^Y Year_t + \sum_j \delta_j^I Industry_j + \epsilon_{jt} \quad (4)$$

$ENTRY_{jt}$ is the total number of entrants in industry j at period t. We include industry dummies to control for industry-specific factors that affect entry, such as different levels of sunk entry costs associated with starting up, say, apparel versus auto parts assembly plants. We also include year dummies to control for aggregate shocks such as exchange rate fluctuations that may affect the entry decision. If intensified Chinese competition discourage entry of new export-assembly plants in Mexico, we expect γ_2 to be negative. We do not use the count data nature of our dependent variable in equation 4, since we use the transformation ln(1+y). We also estimate the entry equation without using the logarithmic transformation with Poisson and negative binomial regressions. Our dependent variable exhibits over-dispersion so we opted for the negative binomial model. In this specification our dependent variable conditional on our regressors assumed to be distributed with Negative Binomial distribution. It is a Poisson-like distribution but unlike Poisson, equi-dispersion (that is, mean equals variance $Var(y_i|x_i) = exp(x_i^{'}\beta)$) is not imposed. Variance is assumed to be $Var(y_i|x_i) = exp(x_i^{'}\beta) + \alpha * (exp(x_i^{'})^2$ where α is an over-dispersion parameter, y is $ENTRY$, and x is our vector of regressors.

Another potential effect of intensified Chinese competition is to cause already existing plants to cease production and exit. We look at the impact of Chinese competition on maquiladora exit using a probit analysis,

$$\chi_{ijst} = \eta_0 + \eta_1 X_{ijst} + \eta_2 Z_{jt} + \eta_3 IMPCH_{jt} + \sum_j \delta_j^I Industry_j + \sum_s \delta_s^S State_s + \sum_t \delta_t^Y Year_t + \epsilon_{ijst} \tag{5}$$

where χ_{ijst} is an indicator for exit decision that takes 1 if plant i ceases its operation next period.

4.3 Productivity

There are mixed empirical evidence whether competition would lead to upgrade of techniques (defensive innovation) or not. We constructed a difference in difference approach to investigate the impact of Chinese competition on the productivity of Mexican maquiladoras.

Our identification strategy is based on the fact that some of the maquiladora sectors which have only very little Chinese presence should not be affected by Chinese accession to WTO as much as sectors with heavy presence of Chinese imports. We constructed three groups, one, $MoreCHT$ where we expect high degree of Chinese Threat, consisting of sectors with more than 6 percent average Chinese share of import-penetration rate at the US market. These are apparel, footwear and leather, electrical machinery and toys and sporting goods. Our second group, $NoCHT$ where we expect minimum Chinese presence and threat, consists of sectors with less than 0.4 percent average Chinese share of import-penetration in the US market. These are Chemicals, Transportation (Auto Parts) and Food products. Our third group which is an excluded group in our regressions consists of furniture and wood products, metal products, computer and electronic accessories, and miscellaneous manufacturing. These are the sectors with medium presence of Chinese presence. [10] Although we base our classification on the import-penetration rate, sectors with tiny presence of Chinese imports are also reflecting the sectors in which Mexico has a comparative advantage due to transportation costs (food, transportation), relative skill-intensity (chemicals, transportation), and also due to the level of protection of the industries (chemicals, transportation).

We then construct our difference in difference estimator as follows:

$$\begin{aligned} lnTFP_{ijst} = \mu_0 + \mu_1 I(WTO) + \mu_2 I(MoreCHT) + \mu_3 I(MoreCHT) * I(WTO) + \mu_4 I(NoCHT) + \\ \mu_5 I(NoCHT) * I(WTO) + \mu_6 X_{ijst} + \sum_j \delta_j^I Industry_j + \sum_s \delta_s^S State_s + \sum_t \delta_t^Y Year_t + \epsilon_{ijst} \end{aligned} \tag{6}$$

$I(WTO)$ is a dummy variable that takes 1 after Chinese accession to WTO, i.e.

[10] We use different thresholds to check the robustness of our results and find that our qualitative results are not sensitive to different thresholds.

$$I(WTO) = 1 \quad \text{if YEAR} \geqslant 2001$$
$$= 0 \qquad \text{otherwise}$$

.

I(MoreCHT) and I(NoCHT) are indicator variables that take 1 if the plant i at period t belongs to the respective groups as defined above. X_{ijst} is a vector of plant-level controls : logarithm of age, multi-plant dummy, entrant dummy (takes 1 if the plant enter that period), and exit dummy (takes 1 if the plant does not participate next period). We also have industry, state and year fixed effects.

In this specification we separate the variation in productivity due to WTO accession of China from other sources by exploiting not only the variation of productivity before and after WTO accession of China, but also across plants that are exposed to Chinese competition with differing degrees.

If there is an overall shift in the productivity after 2001 in all Maquiladoras then the coefficient μ_1 should be positive. Our difference in difference estimates of the effect of Chinese competition are represented by μ_3 and μ_5. The former indicates the productivity differential for sectors with heavy presence of Chinese imports in the corresponding US market compared to the sectors with moderate Chinese imports presence in the US market. The latter indicates the productivity differential between the sectors which are not under the dominance of China compared to the sectors which are moderately affected by Chinese competition.

If Chinese competition makes plants more productive say through upgrading of production techniques, management and organizational skills, the coefficient μ_3 should be positive and the coefficient μ_5 should be negative.

Our regression model identifies the impact of Chinese competition on within productivity as our dependent variable is un-weighted productivity. But productivity will also be affected by reallocation at the extensive margin, that is, through entry and exit of plants. So we include entry and exit dummies to capture these effects.

Competition can also effect productivity through interacting with entry and exit of plants. As competition intensifies, low productivity firms may not be able to compete and exit and this increases aggregate productivity. Another likely consequence is that aggregate productivity increases through entry. This happens if entrant plants are more productive than an average plant. Assume a pool of potential entrants with different productivity levels. If competition decreases average profitability in the industry then the cut-off point of productivity at which potential entrant find entry profitable will be higher, as the expected value of entry becomes lower. We test these hypotheses by including interaction between entry and exit dummies with our WTO dummy.

In our specification in 6, we do not consider intensified competition from China as a gradual change. One way to investigate year by year change is to interact our group dummies with year dummies.

$$\begin{aligned} lnTFP_{ijst} = \mu_0 + \mu_1 I(MoreCHT)_i + \sum_t \mu_{2t} Year_t * I(MoreCHT)_i + \mu_3 X_{ijst} + \\ \sum_j \delta_j^I Industry_j + \sum_s \delta_s^S State_s + \sum_t \delta_t^Y Year_t + \epsilon_{ijst} \end{aligned} \tag{7}$$

In this specification, μ_{2t}, will give the productivity differential between the plants that are exposed to high level of Chinese competition with others at each year t.

As a further check we also estimate the following equation:

$$lnTFP_{ijst} = \nu_0 + \nu_1 IMPCH_{jt} + \nu_2 Z_{jt} + \nu_3 X_{ijst} + \sum_j \delta_j^I Industry_j + \sum_s \delta_s^S State_s + \sum_t \delta_t^Y Year_t + \epsilon_{ijst} \quad (8)$$

We now turn to the results.

5 Results

5.1 Employment Growth

In Table 2 we present the estimation of our employment growth equation. After we control for plant-level variables we find a statistically significant effect of Chinese share of import penetration on Mexican maquiladoras (column 2). In column 3, we additionally control for import penetration rate calculated without Chinese imports, IMP. That both coefficients are negative and significant indicates that import competition in the US market in general is associated with lower employment growth. Although the coefficient of Chinese share is bigger and significant at the 5 % level as opposed to the coefficient of import penetration rate, IMP, which is significant at the 10 %, the Wald test cannot reject that both of the coefficients are equal.

The coefficient in front of the Chinese share of import penetration in column 4 indicates that a one standard deviation increase in Chinese share of import penetration rate is associated with a decrease in annual plant employment growth of 6.2 percentage points.

In columns 5 and 6 of Table 2 we present instrumental variable regression results when we instrument our Chinese imports variable, $IMPCH$, as well as our other import penetration variable, IMP, with the instruments described in the previous section. The results confirm that Chinese imports in the US market are associated with lower employment growth in Maquiladora industries.

Our plant-level coefficients in all of our regressions are significant except the multi-plant dummy and they all have the expected signs. Employment growth increases with productivity, decreases with age, and decreases with size.[11][12]

In Table 3 in columns 1, 2 and 3 we present our results when we interact our Chinese competition proxy with plant TFP, skill intensity as measured by the ratio of non-production workers to production workers and capital intensity as measured by the rental expenditures of machinery, equipment and building to value added respectively. None of the interaction terms are significant, so there is no indication that intensified Chinese competition as proxied with Chinese share of import penetration rate in the US causes disproportionate decrease in employment growth, especially in the group of low-productivity plants, low-skill intensive plants or low capital-intensive plants. This could be expected as the the substitutability between the Chinese export bundle and the Maquiladora export bundle is quite high and there is no apparent ranking between them. That is, we do not expect Chinese exports to the US to exhibit higher substitutability with the lower end of the distribution of maquiladora products in comparison to the upper end for a given industry. Although for example, as Bloom et al. (2009) finds it is more plausible to think that imports from China to Europe compete more with the European firms' products located at the low end of the distribution.

[11]Coefficients of size dummies and multi-plant dummy (additional plant-level controls) are not reported but are available upon request. Size dummies are all negative and significant at the 1 % level. The multi-plant dummy is positive and insignificant.

[12]It is usual to find that younger and smaller firms and plants grow faster conditional on survival (Dunne et al. (1989)). Jovanovic (1982) provides a theoretical foundation through learning.

5.2 Employment at the Extensive Margin

5.2.1 Entry of New Plants

We now turn our attention to the question of whether entry of new plants into the Maquiladora program is affected by intensified Chinese competition. In Table 5 we present the estimates of equation 4. In column 1, we regress $ln(1 + ENTRY_{jt})$ on the Chinese competition proxy and industry fixed effects. We find a negative and significant effect of the Chinese share of import penetration on entry. However, in column 1 we do not control for aggregate factors such as exchange rate fluctuations or policy changes such as implementation of NAFTA that may affect the entry decision in the same way across sectors. In column 2, we additionally control for year fixed effects and our coefficient of interest increased its magnitude.

Can this effect be generalized to imports from everywhere else? Or is it especially true for Chinese competition? We add the import penetration rate in column 3. Interestingly, we find no significant effect of import penetration in the US market on entry of offshoring plants in Mexico. Another potential factor that may affect entry decisions is relative cost of production in the US versus in Mexico. We include industry hourly wages of unskilled workers in the Mexican maquiladora sectors relative to the corresponding US industries in column 4. We find the coefficient of the relative wage negative and significant at the 5 % level. As one may expect, cost factors play an important role for entry of an offshoring plant. One may think that our import-penetration rate for the US industry as described in equation 2 does not abstract the competition effect from other factors that are associated with imports. We use an alternative measure of the 'general level of competitiveness' of the US market in the last column: It is the industry-specific exchange rate constructed using import partner's shares in total imports in the particular US industry, $lnMER$. An increase in this measure refers to the appreciation of the US dollar. We find a negative and significant effect indicating that decrease in the level competitiveness of the US industry is associated with lower rate of entry to the Mexican maquiladoras. But our Chinese share of import penetration rate keeps its sign and significance in column 5.

One criticism to our OLS regressions presented in Table 4 is that entry is a count data and simple transformation of it using logarithm is not appropriate as one may suspect that the error structure may not exhibit normal distribution. We use the count data nature of our variable and estimated the same regressions (without transforming the dependent variable) using Poisson and negative binomial regressions. We present only the negative binomial regression results in Table 5 because our entry variable exhibits over-dispersion. Looking at Table 5, we find results quite similar to the OLS results. We now turn to the impact of Chinese competition on plant exits.

5.2.2 Exit

In Table 5 we present the results from our probit regression for plant exits. In column 1, we regress the exit indicator on plant-level variables that may affect exit decisions and our Chinese competition proxy, China's share of the penetration rate in the US market. Let us first discuss the coefficients of the plant-level variables.

As one may expect we find a significant and negative relationship between exit and size as well as between exit and productivity. We also find evidence of the presence of non-linearities in the relationship between productivity and exit. The impact of productivity on exit diminishes with productivity (negative and significant coefficient of productivity square). Entrants are less likely to exit and as the plants age, the probability of exit increases. These findings indicate that offshoring plant dynamics may be different than the plants that are usually studied using manufacturing survey data. It is typical to find a higher exit rate among younger firms/plants, since they enter without full information about their capabilities or opportunities; so as they age, their likelihood of exit decreases.[13] [14] Offshoring plants on the other hand are mostly owned by large multi-nationals. When an offshoring plant starts an operation it starts with a business tie with a company with safe demand (already accumulated demand) but as time goes by, the offshoring plants' probability to loose the business tie might increase, perhaps due to bankruptcy or other reasons. Our findings indicate a need for a closer look at offshoring plants dynamics.[15] The demand accumulation process is expected to play a minimum role in an offshoring industry like Mexican Maquiladoras, however it is probably an important factor in causing different behavior of plants with different age in the usual manufacturing data.

Turning our attention back to the impact of Chinese competition, we find a positive coefficient of the Chinese penetration rate, however, is not significant. In column 2 we also add the import penetration rate in the US market, IMP. The coefficient is positive and significant at the 10 % level. As the general import-penetration increases in the US market, maquiladora plants' likelihood of exit increases in Mexico. This is probably because, as US firms face lower demand for their products, they consider shutting down their offshoring plants in Mexico.[16] The coefficient of relative wage is positive but insignificant. In column 3 we also present our results when we instrument our Chinese proxy (the Wald test does not reject the exogeneity of Chinese import penetration (p¿0.6738)) with instruments as explained in the previous section. Our results are robust.

As a further robustness check, we also look at the impact of Chinese competition on plant

[13]See for example Dunne et al. (1989) for a study of plant dynamics using the US manufacturing plants.

[14]In the dynamic stochastic industry evolution models, it is usual to assume that potential entrants do not know their own productivity but holds an expectation over it when they make their entry decision, see for example Utar (2007).

[15]In a work-in progress, we are looking further into the dynamics of offshoring industry.

[16]Bergin et al. (2009) documents excess volatility of maquiladoras in comparison to the US counterpart which may imply that the US firms respond to shocks more strongly in their offshoring plants.

exit using the dummy group approach as described in section 4.3. The results of this exercise are presented in Table 10. We find that the probability of exit increases after 2001. The coefficients on the interaction terms have the expected signs: The coefficient of the interaction between the WTO dummy and plants that belong to the most affected sectors is positive; and the coefficient of the interaction between WTO dummy and plants that belong to the non-affected sectors is negative (in comparison to our excluded group). But they are insignificant, confirming our finding with the Chinese share of import-penetration rate. This shows that competition from China is not a significant factor in causing plant exits among Mexican maquiladoras.

5.3 Within Firm Productivity

Our difference in difference estimation results for plant TFP are presented in Table 7. Our TFP measure is calculated separately for each industry allowing differing technologies as described in the Appendix. We include industry fixed effects to control for the variation of productivity levels between industries. We also include time fixed effects to control for common shocks. In column (1) of Table 7 we present the regression result where we only include the top group $MoreCHT$.

We find that the coefficient of the WTO dummy is positive and significant, indicating a general shift in the productivity of export assembly plants in Mexico in 2000s. Indeed, although not reported, we quantified in general 8.6 % increase in the productivity of maquiladora plants after controlling industry and state fixed effects after 2001. It is difficult to attribute this gain to intensified Chinese competition only, as there may be other changes in the aggregate environment that cause a productivity shift in maquiladora plants. One potential explanation is implementation of the rules of origin in 2001 due to NAFTA.[17] However, our difference

[17] Although this rule took place in 2001, subsequent complaints from the maquiladora industries led the

in difference approach will be able to extract the role of Chinese competition from other changes.

The coefficient of the interaction between the WTO dummy and the group of sectors that are under the most direct threat of Chinese competition, $MoreCHT$, is found to be positive and significant. It indicates that the productivity increase after China's accession to WTO is higher for the plants that are belong to the sectors with stronger Chinese comparative advantage. More specifically, after WTO accession of China, productivity of plants in group $MoreCHT$ becomes 5.7 % higher than the productivity of rest of the plants after controlling for aggregate shocks.

The coefficient in front of the entrant dummy is positive and significant at the 10 % level, this is not usual in the firm dynamics literature. We expect that entrants are generally more productive than exiting plants so the turnover rate increases aggregate productivity. However, net entry is generally thought to be a negative contributor to the aggregate productivity as new entrants are on average found to be less productive than the average.[18] However, all empirical findings until now has been based on manufacturing firms and we do not know any study that investigates plant dynamics in an offshoring industry. [19] If demand accumulation process does not play a significant role among offshoring plants, as we discussed in the previous section, then we do not expect younger plants to charge a lower price than the older plants, everything else is being constant. Accordingly, our productivity estimates will not underestimate the productivity of entrants due to omitted price problem. So in one sense, we confirm the findings of Foster et al. (2008) that entrants are not necessarily less

Mexican government put an exemption on maquiladora plants. One may also argue, the rules of origin would lead decrease in productivity rather than increase as it would decrease the diversity of imports.

[18]Foster et al. (2008) and Foster et al. (2009) find on the other hand that entrants are not necessarily less productive than the incumbent plants after controlling for demand side factors.

[19]In an accompanying paper where we analyze productivity dynamics of offshoring industry, we find that non-negative contribution of entry is robust to different productivity estimates.

productive than the incumbents after controlling for demand disadvantages of entrants.

The exit dummy is negative indicating that, on average, exiting plants are less productive, but this coefficient is not found to be statistically significant. This is in line with our previous findings that aggregate demand factors are playing a role in plant exits as well as there are non-linearities in the relationship between productivity and exit.

In column (2) of Table 7 we repeat the same analysis for the group of plants that belong to the least affected sectors, $NoCHT$. We find that the interaction between the WTO dummy and $NoCHT$ is negative and significant. More specifically, plants that belong to the sectors where Chinese comparative advantage is not strong (Chemicals, Transportation and Food), are on average 6.1 % less productive in comparison to the rest of the plants after China's accession to WTO.

In column (3), we included both groups, $MoreCHT$, and $NoCHT$, so that the interaction terms will indicate the productivity differential between that group and the excluded group, which is the group with medium exposure to Chinese imports. The coefficient of the WTO dummy is positive and significant, indicating that productivity increases 8 % on average after China's accession. The coefficient of $MoreCHT * WTO$ is positive and significant, and the coefficient of $NoCHT * WTO$ is negative and significant. Our difference in difference estimates confirm that heightened Chinese competition leads to within firm productivity increase in Mexican maquiladoras.

Does the competition have effect on productivity through entry and exit? Column (4) of Table 7 shows that the coefficient of the entrant dummy looses its significance after inclusion of the interaction between entry and WTO dummies. Instead, the coefficient of the interaction effect becomes positive and significant, indicating that after 2001 entrants started to become more productive. It is interesting that the most of the positive effect of entry is indeed after the competition with China is intensified. We find support for a hypothesis that intensified competition with China increases the cut-off level of productivity at which a potential entrant will be indifferent between starting up a plant or not. Only plants with a high level of productive opportunities enter. We also look at the skill intensity (non-production workers over production workers)of the entrants and find that the mean skill-intensity of entrants before 2001 is 0.339 and the mean intensity of entrants after 2001 is 0.609 which supports our finding with productivity levels. This is not due lower size of entrants after 2001 since the mean size of entrants slightly increases in comparison to pre-2001 level too. This is also in line with Heckscher-Ohlin theory which suggests growth in skill-intensive jobs in Mexico as a result of competition from low skill intensive China.[20]

Looking at exit, after inclusion of interaction, the exit dummy becomes significant (and negative) at the 10 % level. The coefficient of the interaction between exit and WTO is positive but insignificant. This could be due to US firms shutting down its sufficiently productive plants in Mexico and moving them to China as trade costs with China decrease.[21]

From Column (5) through column(8) we repeat the analysis with the inclusion of plant-fixed effects. In these regressions the time-invariant variables were removed due to the inclusion of deterministic fixed effects. The basic picture does not change. That, there is significant within productivity improvement after 2001 and this effect is stronger for the plants with more exposure to Chinese imports. Moderately productive plants cease production as probably some of the multi-national firms move labor intensive production stages from Mexico to cheaper places, such as China.

What is the over-time impact of Chinese accession to WTO on the productivity of Mexican

[20]Indeed, among continuing plants, skill-intensity is on average 0.28 before 2001 in comparison to 0.38 after 2001.

[21]Again we should be careful not to over-interpret our results, since the interaction term is found to be insignificant. However, interaction between exit and the WTO dummy becomes significant once we include our plant-level fixed effects.

maquiladoras? The results presented in Table 8 tell us that the effect of competition on productivity increases over time as China performs better and better each year. The productivity differential of the most effected group of plants and the rest of the maquiladoras is 7.3 % on average in 2002, and this becomes 9.1 % on average in 2005 (column 1). To be able to extend the years until 2006, exit dummy is excluded in column 2. The results are similar. The estimates are also robust to the inclusion of plant fixed effects (column (3) and (4)).

In Table 9 we present our results when using the continuous proxy for Chinese competition, Chinese import penetration in the US market, $IMPCH$. In column (1), the coefficient of $IMPCH$ implies that one standard deviation increase in Chinese import penetration in the US market increases the productivity of maquiladoras by 10.2 percentage points. When we control for import-penetration rate (imports from everywhere else), one standard deviation increase in Chinese import-penetration increases productivity by 12.6 percentage points (column (2)). When we add interaction of our entry and exit dummies with the Chinese competition proxy (columns 3 and 4) we confirm our previous findings in Table 7. As competition becomes tougher, the contribution of entry to the aggregate productivity increases as a more selective group of potential entrants choose to enter (Schumpeterian effect). We also confirm our findings about exit, that intensified exit due to competition does not necessarily affect low productivity plants. Indeed, it seems that Chinese competition is associated with exiting plants that are on average more productive than the survivals as the interaction between exit dummy and $IMPCH$ is positive and significant. Again this maybe because of firm-level adjustment to lower trade costs in China. As China becomes a cheaper destination to offshore to, some firms may want to move their plants from Mexico to China. Since this is a fixed cost activity, we may expect that only more productive firms will choose to relocate their plants across different destinations (shutting down a maquiladora and opening up a plant in China), while less productive ones may choose to respond at the intensive margin.

6 Conclusion

We analyze the impact of Chinese competition on Mexican export assembly plants, (Maquiladoras) using plant-level data set that covers the period from 1990 to 2006. We find that employment growth and entry are negatively affected by Chinese competition. We quantified a positive, and both economically and statistically significant productivity improvement in Mexican maquiladoras in 2000s. We also quantified significant and positive effect of intensified Chinese competition on within productivity of Mexican maquiladoras. The results provide evidence in support of models that imply a positive relationship between international competition and within firm productivity.

We also highlight that offshoring plants dynamics exhibit different patterns in contrast to the plant dynamics mostly studied in manufacturing survey data. We find that entrants are not necessarily less productive than incumbent plants. We also find probability of exit increases with plants' age. More specifically, the lack of demand accumulation concerns among offshoring plants could be one factor that drive differences.

The results also indicate that plant exit decisions are given at the firm-level. Relocation of plants from one location to another may imply that firms choose to relocate are more productive than ones choose to respond to intensified competition from China at the intensive margin due to sunk costs associated with relocation.

Overall we identify an interesting link between competition between two popular offshoring destinations for the US firms (Mexico and China) and within plant productivity improvement that may relieve some of the worries that Mexican policy makers express over growing trade from China.

References

[1] Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith and Peter Howitt (2005), "Competition and Innovation: An Inverted-U Relationship", *The Quarterly Journal of Economics*

[2] Arrow, Kenneth (1962), "Economic Welfare and Allocation of Resources for Invention", appeared in *The Rate and the Direction of the Inventive Activity*, Princeton University Press, p. 609-626.

[3] Bergin, Paul, Robert Feenstra, and Gordon Hanson, "Outsourcing and Volatility", forthcoming in *American Economic Review.*

[4] Bernard, Andrew B, Bradford Jensen, and Peter K. Schott (2006), "Survival of the Best Fit: Exposure to Low-Wage Countries and the (uneven) Growth of U.S. Manufacturing Plants", *Journal of International Economics*, 68, p. 219-237.

[5] Bloom, Nicholas, Mirko Draca, John Van Reenen (2009), "Trade induced technical change? The impact of Chinese imports on innovation and information technology", Working Paper, Stanford University.

[6] Canas, Jesus, and Roberto Coronado (2002), "Maquiladora Industry: Past, Present and Future", *El Paso Business Frontier*, Federal Reserve Bank of Dallas, El Paso Branch.

[7] Caves, W. Douglas, R. Laurits Christensen, and W. Erwin Diewert (1982) "The Economic Theory of Index Numbers and Measurement of Input, Output and Productivity", *Econometrica*, Vol 50, No:6, pp-1393-1414.

[8] Devlin, Robert, Antoni Estevadeordal and Andrés Rodríguez-Clare (2006), *The Emergence of China: Opportunities and Challenges for Latin America and the Caribbean*, Washington D.C.: Inter-American Development Bank.

[9] Dixit, Avinash, and Joseph Stiglitz (1977) ”Monopolistic Competition and Optimum Product Diversity”, *American Economic Review*, Vol 67, pp-297-308.

[10] Dunne, Timothy, Mark J. Roberts, and Larry Samuelson (1989), ”The Growth and Failure of US Manufacturing Plants”, *The Quarterly Journal of Economics*, Vol. 104, No: 4, pp. 671-698.

[11] Foster, Lucia, John Haltiwanger, and Chad Syverson (2008) ”Reallocation, Firm Turnover and Efficiency: Selection on Productivity or Profitability?, *American Economic Review*

[12] Foster, Lucia, John Haltiwanger, and Chad Syverson (2009) ”The Slow Growth of New Plants: Learning about Demand?”, working paper.

[13] Goldberg, Linda (2004), ”Industry-Specific Exchange Rate for the United States”, *FRBNY Economic Policy Review*

[14] Good, D., Ishaq Nadiri and R. Sickles (1997), ”Index Number and Factor Demand Approaches to the Estimation of Productivity”, H. Pesaran and P. Schmidt, eds. Handbook of Applied Econometrics Vol. II-Microeconometrics, Malden, MA: Blackwell Publishers, 14-80.

[15] Gruben, William C. (2001), ”Was NAFTA Behind Mexico's High Maquiladora Growth”, *Economic and Financial Review*, Third Quarter, Dallas FED.

[16] Hanson, Gordon and Raymond Robertson (2008), ”China and the Manufacturing Exports of Other Developing Countries”, NBER Working papers No 14497.

[17] Hart, Oliver (1983), ”The Market Mechanism as an Incentive Scheme”, *The Bell Journal of Economics*, Vol. 14, No. 2, pp. 366-382

[18] Hermalin, E. Benjamin (1992), "The Effects of Competition on Executive Behavior" *The RAND Journal of Economics*, Vol. 23, No. 3, pp. 350-365

[19] Horn, Henrik, Harald Lang, and Stefan Lundgrena (1995) "Managerial effort incentives, X-inefficiency and international trade", *European Economic Review* Volume 39, Issue 1, January 1995, Pages 117-138

[20] Jovanovic, Boyan (1982),"Selection and the Evolution of Industry", *Econometrica*, Vol. 50, No. 3, pp. 649-670

[21] Lindquist, Diane (2004), "The Maquiladora Roars Back", *The San Diego Union Tribune*, June 29, 2004.

[22] Lopez-Cordova, J. Ernesto, Alejandro Micco and Danielken Molina (2008), "How Sensitive are Latin American Exports to Chinese Competition in the U.S. Market?", World Bank Policy Research Working Paper Series, No 4497.

[23] Salop, Steven (1977), "The Noisy Monopolist: Imperfect Information, Price Dispersion and Price Discrimination", *The Review of Economic Studies*, Vol. 44, No. 3, pp. 393-406

[24] Scharfstein, David (1988) "Product-market competition and managerial slack" *Rand Journal of Economics* 19, pp. 147155.

[25] Truett, Lila, and Dale Truett (2007), "NAFTA and The Maquiladoras: Boon or Bane?" *Contemporary Economic Policy*, Vol. 25, No. 3, pp. 374-386

[26] Utar, Hâle (2007), "Import Competition and Employment Dynamics", mimeo, University of Colorado.

7 Appendix

7.1 Tables and Figures

Table 1: Descriptive Statistics of the Plant Level Data Set

	Mean	Standard Deviation	Median	Observation
Labor (total hours)	769179.1	1744475	219399	27548
Production Workers	288	658.3	82	27548
Non-Production Workers	75	186.4	16.6	27548
Materials	187436	724008.8	16754.2	27548
Capital	1763.2	3965.8	363.5	27548
Value Added	50703.3	123993.4	12581	27548
Gross Output	242820.8	818301.6	31962.5	27548

Note: Values are expressed in thousand 2002 Mexican peso.

Table 2: The Impact of Chinese Competition on Employment I

	(1)	(2)	(3)	(4)	(5)	(6)
Specification	OLS	OLS	OLS	OLS	IV	IV
Dependent Variable	ΔlnE	ΔlnE	ΔlnE	ΔlnE	ΔlnE	ΔlnE
$IMPCH_{jt-1}$	-0.488	-0.725	-1.052	-1.059	-1.190	-1.239
	(0.357)	(0.308)*	(0.329)**	(0.429)**	(0.454)***	(0.330)***
IMP_{jt-1}			-0.757	-0.789		-0.939
			(0.328)*	(0.352)*		(0.217)***
$lnTFP_{ijst-1}$		0.131	0.123	0.124	0.121	0.132
		(0.035)***	(0.033)***	(0.033)***	(0.027)***	(0.027)***
$LogAge_{ijst-1}$		-0.813	-0.808	-0.809	-0.813	-0.811
		(0.029)***	(0.028)***	(0.028)***	(0.017)***	(0.017)***
Additional Plant-Level Controls	No	Yes	Yes	Yes	Yes	Yes
Additional Industry-Level Controls	No	No	No	Yes	No	No
State-Year Fixed Effects	✓	✓	✓	✓	✓	✓
Plant Fixed Effects	✓	✓	✓	✓	✓	✓
Number of Plants	3540	3122	3122	3122	2643	2578
Number of Observations	23743	18525	18525	18525	18046	17277
R^2	0.1232	0.3086	0.3094	0.3094	0.3085	0.3142
$SheaPartialR^2$					0.3088	0.6954-0.8060
Sargan Test					0.029 ($\chi(1)$)	4.610($\chi(3)$)

Note: Dependent variable is the change in the employment between t and t+1. Robust standard errors are reported in parentheses. For the OLS estimates standard errors are clustered for each industry in each year. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Additional plant-level controls include size dummies, and multi-plant dummy which is an indicator variable if the plant is a part of multi-plant company. Additional industry-level controls include Mexican industry hourly wages relative to the US industry, and production index of the US industry. For IV regressions instruments we use are explained in the text. Constant is included but not reported.

Table 3: The Impact of Chinese Competition on Employment II

Dependent Variable	ΔlnE	ΔlnE	ΔlnE
$IMPCH_{jt-1}$	-0.951	-1.034	-1.202
	$(0.344)^{**}$	$(0.412)^{*}$	$(0.453)^{**}$
IMP_{jt-1}	-0.738	-0.880	-0.837
	$(0.354)^{*}$	$(0.366)^{*}$	$(0.352)^{*}$
$lnTFP_{ijt-1}$	0.172	0.089	0.103
	$(0.042)^{***}$	$(0.038)^{*}$	$(0.039)^{**}$
Skill Intensity $\log(\text{NP/P})_{ijt-1}$		0.007	
		(0.015)	
Capital Intensity $\log(\text{K/Y})_{ijt-1}$			0.006
			(0.005)
$IMPCH_{jt-1} * lnTFP_{ijt-1}$	-0.797		
	(0.520)		
$IMPCH_{jt-1} *$ Skill Intensity $\log(\text{NP/P})_{ijt-1}$		-0.006	
		(0.180)	
$IMPCH_{jt-1} *$ Capital Intensity $\log(\text{K/Y})_{ijt-1}$			-0.033
			(0.070)
Plant-Level Controls	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes
State-Year Fixed Effects	✓	✓	✓
Plant Fixed Effects	✓	✓	✓
Number of Plants	3122	3101	3090
Number of Observations	18525	18439	18393
R^2	0.3095	0.3087	0.3067

Note: Dependent variable is the change in the employment between t and t+1. Robust standard errors are reported in parentheses. They are clustered for each industry in each year. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Plant-level controls include multi-plant dummy and size dummies and logarithm of age. Industry-level controls include Mexican industry hourly wages relative to the US industry, and production index of the US industry. Constant is included but not reported.

Table 4: The Impact of Chinese Competition on Entry to Mexican Offshoring Industry

	(1)	(2)	(3)	(4)	(5)
Specification	OLS	OLS	OLS	OLS	OLS
Variables	$ln(ENTRY+1)$	$ln(ENTRY+1)$	$ln(ENTRY+1)$	$ln(ENTRY+1)$	$ln(ENTRY+1)$
IMPCH	-2.318	-3.972	-4.042	-3.738	-3.266
	(0.659)***	(0.994)***	(1.087)***	(0.963)***	(0.989)**
IMP			-0.170		
			(0.856)		
Relative Wage ($\frac{MxWage_{jt}}{USWage_{jt}}$)				-1.894	-1.769
				(0.633)**	(0.696)*
Industry Specific Exchange Rate ($lnMER_jt$)					-2.939
					(1.071)**
Industry Fixed Effects	✓	✓	✓	✓	✓
Year Fixed Effects	No	✓	✓	✓	✓
N	176	176	176	176	176
R^2	0.815	0.845	0.846	0.851	0.858

Dependent variable is the logarithm of one plus the total number of entrants at period t and industry j. Robust standard errors are reported in parentheses. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported.

Table 5: The impact of Chinese Competition on Entry to Mexican Offshoring Industry

	(1)	(2)	(3)	(4)	(5)
Specification	Negative Binomial	Negative Binomial	Negative Binomial	Negative Binomial	Negative Binomial
Variables	*ENTRY*	*ENTRY*	*ENTRY*	*ENTRY*	*ENTRY*
IMPCH	-3.088	-6.740	-7.087	-6.632	-5.543
	(0.766)***	(1.141)***	(1.157)***	(1.140)***	(1.165)***
IMP			-1.163		
			(0.733)		
Relative Wage ($\frac{MXWage_{jt}}{USWage_{jt}}$)				-1.932	-2.070
				(0.881)*	(0.902)*
Industry Specific Exchange Rate ($lnMER_{jt}$)					-3.219
					(0.980)**
$ln(\alpha)$ (over-dispersion parameter)	-2.326	-3.041	-3.124	-3.053	-3.216
	(0.183)***	(0.267)***	(0.295)***	(0.265)***	(0.284)***
Industry Fixed Effects	✓	✓	✓	✓	
Year Fixed Effects	No	✓	✓	✓	
N	176	176	176	176	176
Log pseudolikelihood	-507.822	-484.301	-483.246	-482.293	-477.275

Dependent variable is the total number of entrants at period t and industry j. Robust standard errors are reported in parentheses. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported.

Table 6: Probit Estimates:Plant Exits

	(1)	(2)	(3)
Specification	Probit	Probit	IV
Variables	χ	χ	χ
IMPCH	0.723	1.251	1.145
	(0.957)	(0.911)	(1.389)
IMP		1.236	
		(0.543)*	
Relative Wage ($\frac{MXWage_{jt-1}}{USWage_{jt-1}}$)		0.757	
		(0.465)	
Log Labor	-0.385	-0.386	-0.385
	(0.019)***	(0.019)***	(0.019)***
Productivity	-0.259	-0.266	-0.260
	(0.092)**	(0.093)**	(0.092)***
Productivity Square	0.300	0.304	0.301
	(0.066)***	(0.066)***	(0.066)***
Log Age	0.170	0.171	0.169
	(0.038)***	(0.038)***	(0.038)***
Entrant Dummy	-0.693	-0.686	-0.694
	(0.096)***	(0.096)***	(0.096)***
Multi-plant Dummy	0.035	0.034	0.035
	(0.43)	(0.43)	(0.43)
State Fixed Effects	✓	✓	✓
Industry Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
N	18907	18907	18907
Pseudo R^2	0.2242	0.2253	

Robust standard errors are reported in parentheses. They are clustered for each industry in each year. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported. In the IV regression, Wald test does not reject exogeneity of $IMPCH$.

Table 7: The Impact of Chinese Competition on Productivity I

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP
WTO	0.069	0.093	0.081	0.074	0.126	0.141	0.136	0.143
	(0.013)***	(0.013)***	(0.013)***	(0.013)***	(0.034)***	(0.034)***	(0.034)***	(0.034)***
MoreCHT	-0.170		-0.158	-0.159				
	(0.077)*		(0.020)***	(0.020)***				
MoreCHT*WTO	0.057		0.046	0.044	0.043		0.035	0.034
	(0.013)***		(0.014)***	(0.014)***	(0.012)***		(0.012)**	(0.012)**
NoCHT		0.175	0.025	0.025				
		(0.078)*	(0.077)	(0.077)				
NoCHT*WTO		-0.061	-0.048	-0.048		-0.041	-0.032	-0.031
		(0.015)***	(0.015)**	(0.015)**		(0.014)**	(0.014)*	(0.014)*
Log Age	-0.003	-0.002	-0.002	-0.001	-0.023	-0.023	-0.024	-0.026
	(0.006)	(0.006)	(0.006)	(0.006)	(0.013)	(0.013)	(0.013)	(0.013)*
Multi-Plant Dummy	0.030	0.030	0.030	0.030	0.019	0.018	0.019	0.019
	(0.009)***	(0.009)***	(0.009)***	(0.009)***	(0.012)	(0.012)	(0.010)	(0.012)
Entrant Dummy	0.023	0.023	0.023	0.010	0.009	0.009	0.013	-0.001
	(0.010)*	(0.010)*	(0.010)*	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Entrant*WTO				0.046				0.030
				(0.018)**				(0.017)
Exit Dummy	-0.016	-0.016	-0.017	-0.033	0.010	0.011	0.010	-0.018
	(0.011)	(0.011)	(0.011)	(0.016)*	(0.009)	(0.009)	(0.009)	(0.011)
Exit*WTO				0.028				0.044
				(0.022)				(0.017)*
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
State Fixed Effects	✓	✓	✓	✓	No	No	No	No
Industry Fixed Effects	✓	✓	✓	✓	No	No	No	No
Plant Fixed Effects	No	No	No	No	✓	✓	✓	✓
Number of Plants	3116	3116	3116	3116	3116	3116	3116	3116
Number of Observations	18907	18907	18907	18907	18907	18907	18907	18907
R^2	0.199	0.199	0.202	0.202	0.042	0.041	0.043	0.044

Note: Dependent variable is the logarithm of productivity. Robust standard errors are reported in parentheses. They are clustered for plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported.

Table 8: The Impact of Chinese Competition on Productivity II

Dependent Variable	(1) lnTFP	(2) lnTFP	(3) lnTFP	(4) lnTFP
MoreCHT	-0.177	-0.177		
	(0.080)*	(0.045)**		
MoreCHT*1992	0.007	0.006	0.002	0.002
	(0.017)	(0.017)	(0.014)	(0.014)
MoreCHT*1993	-0.012	-0.013	-0.016	-0.016
	(0.020)	(0.020)	(0.017)	(0.017)
MoreCHT*1994	0.016	0.016	0.011	0.011
	(0.023)	(0.023)	(0.018)	(0.018)
MoreCHT*1995	0.005	0.005	0.019	0.019
	(0.023)	(0.023)	(0.020)	(0.020)
MoreCHT*1996	-0.002	-0.002	0.020	0.020
	(0.023)	(0.024)	(0.021)	(0.021)
MoreCHT*1997	0.022	0.021	0.021	0.021
	(0.024)	(0.024)	(0.022)	(0.022)
MoreCHT*1998	0.017	0.016	0.006	0.006
	(0.024)	(0.024)	(0.021)	(0.021)
MoreCHT*1999	0.025	0.024	0.028	0.029
	(0.025)	(0.025)	(0.021)	(0.021)
MoreCHT*2000	0.001	0.000	0.002	0.002
	(0.024)	(0.024)	(0.020)	(0.021)
MoreCHT*2001	0.035	0.033	0.028	0.029
	(0.026)	(0.026)	(0.023)	(0.023)
MoreCHT*2002	0.073	0.071	0.065	0.067
	(0.028)*	(0.028)*	(0.025)**	(0.025)**
MoreCHT*2003	0.065	0.063	0.063	0.065
	(0.028)*	(0.028)*	(0.025)*	(0.025)**
MoreCHT*2004	0.080	0.078	0.069	0.070
	(0.026)**	(0.026)**	(0.025)**	(0.025)**
MoreCHT*2005	0.091	0.088	0.081	0.080
	(0.029)**	(0.029)**	(0.026)**	(0.026)**
MoreCHT*2006		0.091		0.091
		(0.025)***		(0.025)***
Log Age	-0.002	0.001	-0.023	-0.024
	(0.006)	(0.006)	(0.013)	(0.012)
Multi-Plant Dummy	0.030	0.028	0.020	0.021
	(0.009)***	(0.008)***	(0.012)	(0.011)
Entrant Dummy	0.023	0.027	0.009	0.008
	(0.010)*	(0.009)**	(0.010)	(0.010)
Exit Dummy	-0.017		0.010	
	(0.011)		(0.009)	
Year Fixed Effects	✓	✓	✓	✓
State Fixed Effects	✓	✓	No	No
Industry Fixed Effects	✓	✓	No	No
Plant Fixed Effects	No	No	✓	✓
Number of Plants	3116	3116	3116	3116
Number of Observations	18907	18907	18907	18907
R^2	0.201	0.208	0.041	0.043

Note: Dependent variable is the logarithm of productivity. Robust standard errors are reported in parentheses. They are clustered for plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported. In columns (2) and (4) we exclude exit dummy in order to include Year 2006 dummy, since exit is not defined in 2006 as we do not observe 2007.

Table 9: The Impact of Chinese Competition on Productivity III

	(1)	(2)	(3)	(4)
Dependent Variable	lnTFP	lnTFP	lnTFP	lnTFP
IMPCH	0.489	0.606	0.542	0.455
	(0.136)***	(0.125)***	(0.126)***	(0.125)***
IMP		0.308	0.300	0.190
		(0.068)***	(0.068)***	(0.093)*
Log Age	-0.003	-0.002	-0.002	-0.023
	(0.004)	(0.004)	(0.004)	(0.009)*
Multi-Plant Dummy	0.030	0.030	0.029	0.019
	(0.005)***	(0.005)***	(0.005)***	(0.007)**
Entrant Dummy	0.023	0.024	0.013	-0.005
	(0.010)*	(0.010)*	(0.013)	(0.011)
Entrant*IMPCH			0.197	0.265
			(0.122)	(0.115)*
Exit Dummy	-0.015	-0.017	-0.047	-0.029
	(0.013)	(0.013)	(0.017)**	(0.011)*
Exit*IMPCH			0.393	0.498
			(0.163)*	(0.127)***
Year Fixed Effects	✓	✓	✓	✓
State Fixed Effects	✓	✓	✓	No
Industry Fixed Effects	✓	✓	✓	No
Plant Fixed Effects	No	No	No	✓
Number of Plants	3116	3116	3116	3116
Number of Observations	18907	18907	18907	18907
R^2	0.200	0.201	0.202	0.043

Note: Dependent variable is the logarithm of productivity. Robust standard errors are reported in parentheses. They are clustered for each industry in each year. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported.

Table 10: Probit Estimates:Plant Exits– Robustness Check with Dummy Variable Approach

	(1)	(2)	(3)
Specification	Probit	Probit	Probit
Variables	χ	χ	χ
WTO	0.405	0.458	0.423
	(0.126)**	(0.125)***	(0.127)***
WTO*MoreCHT	0.132		0.115
	(0.074)		(0.077)
WTO*NoCHT		-0.128	-0.090
		(0.099)	(0.103)
MoreCHT	0.287		0.168
	(0.169)		(0.137)
NoCHT		-0.252	-0.026
		(0.146)	(0.153)
Lagged Size	-0.385	-0.385	-0.385
	(0.016)***	(0.016)***	(0.016)***
Lagged Productivity	-0.262	-0.261	-0.264
	(0.082)**	(0.081)**	(0.082)**
Lagged Productivity Square	0.302	0.302	0.303
	(0.058)***	(0.057)***	(0.058)***
Lagged Log Age	0.170	0.171	0.170
	(0.036)***	(0.035)***	(0.036)***
Entrant Dummy	-0.692	-0.692	-0.692
	(0.089)***	(0.088)***	(0.089)***
Multi-plant Dummy	0.036	0.035	0.036
	(0.044)	(0.044)	(0.44)
State Fixed Effects	✓	✓	✓
Industry Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
N	18907	18907	18907
Pseudo R^2	0.2245	0.2243	0.2246

Robust standard errors are reported in parentheses. They are clustered for plants. *, ** and *** indicate significance at the 10 %, 5% and 1% levels respectively. Constant is included but not reported.

7.2 Calculation of Plant TFPs

We use KLEM approach and calculate multi-factor productivity using gross-output measures. Good, Nadiri and Sickles (1997) discusses the extension of the total factor productivity index that incorporates both the chaining approach and the hypothetical firm approach of Caves, Christensen and Diewert (1982) that is suitable for panel data-setting. We construct a hypothetical firm whose subcomponent expenditure shares are the arithmetic mean expenditure shares and whose subcomponent quantities are the geometric means of the subcomponent quantities for each cross section. We then chain the hypothetical firms together over time.

$$\begin{aligned} lnTFP_{jt} = (q_{jt} - \overline{q_t}) + \sum_{s=2}^{t}(\overline{q_s} - \overline{q}_{s-1}) - [\sum_{i=k,l,e,m} 0.5 * (\alpha^i_{jt} + \overline{\alpha^i_t})(x^i_{jt} - \overline{x^i_{jt}}) + \\ \sum_{s=2}^{t} \sum_{i=k,l,e,m} 0.5 * (\overline{\alpha^i_s} + \overline{\alpha^i_{s-1}})(\overline{x^i_s} - \overline{x^i_{s-1}})] \end{aligned} \quad (9)$$

where q_{it} is the logarithm of deflated sales of plant j, and x^i_{jt} is the logarithm of the input i used by plant j at period t where type of input is indicated with superscript $i = k, l, e, m$. l denotes labor measured by the total number of hours worked, k denotes capital measured by the deflated rental expenditures on buildings, machinery and equipment, e denotes energy measured by deflated expenditures on fuel and electricity and m denotes materials measured by deflated expenditures on domestic and imported materials. The bar indicates an average over the relevant variable (e.g. $\overline{q_t}$ indicates the natural logarithm of the geometric average for output across all plants at period t). Scale elasticity α's are calculated using costs shares.

7.3 Sources and construction of the Data

7.3.1 Matching NAICS with Maquiladoras

The 11 maquiladora industries where matched with their closest 3-digit NAICS matches (See Table 11). To do so, maquila export trade data in 2-digit Harmonized System(HS) as reported by Banco de México was converted to 3-digit NAICS. In the case of the maquiladora industry, assembly and repair of tools, equipment and parts with the exception of electronic equipment (ecogroup 7), was matched with three different NAICS industries 331-333, it is represented by all three of these industries. This was the only industry that was matched with more than one 3-digit NAICS industry. Each matched industry is assigned a weight based on the share of the exports of that particular industry among overall exports from ecogroup 7. These weights were then used to estimate import penetration, U.S. industrial production and U.S wages for 331-333. As well as any other variable with NAICS classification 331-333.

Table 11: Industry Descriptions

Description	NAICS Code
Selection, preparation, packing and canning of food	311
Assembly of clothing and other products made with textiles and other materials	315
Manufacturing of footwear and leather industry	316
Assembly of furniture, accessories and other wood and metal products	337
Chemical products	325
Construction, reconstruction and assembly of transportation	336
Equipment and accessories assembly and repair of tools, equipment and parts with the exception of electric and electronic equipment	331-333
Assembly of electrical machinery, equipment, devices and & appliances	334
Computer and electronic materials and accessories	335
Assembly of toys and sporting goods	3399
Other manufacturing industries	339

7.3.2 Exchange Rates

We use industry-specific exchange rate measures for the US manufacturing industries constructed by Linda Goldberg. The data can be downloaded from `http://www.newyorkfed.org/research/global_economy/industry_specific_exrates.html` These measures are constructed by using the time histories of the weights of U.S. trading partners in the exports and imports of each U.S. industry. Each industry is denoted by an index i and each country/trade partner of that industry by an index c. The industry-specific real exchange rate indexes depart from the aggregate indexes in that the weights of each partner currency (country c) are the shares of that partner c in the U.S. exports or imports of that specific industry i.

7.3.3 Import Penetration Rates and other Aggregate Variables

To calculate import penetration in the U.S., data from the Center for International Data at U.C. Davis on exports and imports by industry and country was used. The information is provided in 6-digit NAICS classification. The data was then aggregated to 3- digit NAICS. Output information is provided by the Bureau of Economic Analysis(BEA) in 3-digit NAICS format.

3-digit NAICS U.S. hourly wages data is taken from the Bureau of Labor Statistics(BLS). To estimated maquiladora hourly wages, total worker wages were divided by total hours worked by workers. Since they are in Mexican pesos they were then divided by the nominal exchange rate and aggregated to industry-level. The source for the nominal exchange rate between the US dollar and Mexican peso is Banco de México. Relative wages is then constructed by dividing Mexican hourly wage by the their U.S. industry counterpart. Both US and maquiladora wages do not include benefits to workers. The source for U.S. industrial production is the Federal Reserve Board of Governors. The information is presented annually with 3-digit NAICS classification.