

# The Heterogeneous Impacts of Offshoring on Wages and Employment

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October 21, 2008

## Abstract

*Offshoring of US jobs to Mexico and elsewhere is controversial. Critics have been concerned that offshoring could lead to lost jobs and lower wages at firms that offshore relative to those that do not. Such a story, it turns out, is appealing, intuitive, and mistaken. In this paper, I develop a new theory of offshoring built on heterogeneous firms and wage bargaining, in which firms endogenously select into offshoring. Given a new opportunity to offshore, the theory predicts that wages rise at firms that offshore relative to wages at firms that do not. The theory also predicts that total employment could rise or fall at firms that offshore, but will definitely fall at firms that fail to offshore. Using the Mexican FDI Law of 1993 and the peso crisis in 1994 as exogenous shocks to the costs of offshoring to Mexico, I proceed to test these implications with firm-level data. The empirical findings confirm the prediction that wages will rise at offshoring firms relative to those that do not. The results also reveal that, while there are some jobs lost at both types of firms, there is no evidence of significantly greater job loss at firms that offshore relative to those that do not.*

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\*Thanks to Donald Davis and Eric Verhoogen for their guidance. Also, I would like to thank Kyle Bagwell, Amit Khandelwal, Yoichi Sugita, Kensuke Teshima, other participants in the Columbia Trade Colloquium, John Stevens, Sanjay Chugh, other participants in the DC Fed IF Group Seminar, and colleagues at Columbia University for helpful comments along the way. Finally, I would like to thank William Zeile and Ray Mataloni at the Bureau of Economic Analysis for providing me with access to and assistance with the BEA data.

## **I - Introduction**

Offshoring<sup>1</sup> has been a source of controversy under the charge that it hurts the American worker. This view, popularized by Lou Dobbs (2004), contends that firms who offshore reduce wages and shed jobs. Hence, it was no surprise that Gregory Mankiw, while serving as chairman of the CEA, caused an uproar by commenting that offshoring is only “the latest manifestation of the gains from trade that economists have talked about at least since Adam Smith”. As economists and others have noted, trade can lead to welfare gains in the aggregate but produces “winners” and “losers”. If offshoring is the latest manifestation of gains from trade, then who are the winners and losers? The paper develops a new theoretical framework to answer this question and provides empirical support for the predictions, which challenge popular conceptions of offshoring. The main finding is that, contrary to popular beliefs, firms who offshore increase wages, especially relative to firms who do not offshore. Furthermore, while employment loss could occur at offshoring firms, there is no evidence that there is greater job loss at these firms compared to firms who do not offshore.

The notion that offshoring eliminates jobs and places downward pressure on wages has some economic merit. The most basic argument would be that offshoring substitutes for domestic labor causing the firm’s labor demand curve to shift in and lower wages. In support, Harrison and McMillan (2006) present evidence that vertical FDI indeed serves as a substitute for domestic labor. Also, the labor demand effect could operate through changes in relative prices by placing offshoring in a standard Heckscher-Ohlin framework. Rodrik (1997), and Dube and Reddy (2006) argue that globalization can have negative effects on low-skilled domestic workers by shifting bargaining power away from workers towards firms. Slaughter (1997), (2007) and others have offered some empirical evidence suggesting support of this argument. However, these arguments constitute only part of the story. In a recent paper, Grossman and Rossi-Hansberg (2006) compare offshoring to a technology as both reduce costs/increase productivity for a firm. This

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<sup>1</sup>I follow Trefler (2005)’s definition for offshoring, which includes the movement of production processes abroad (vertical FDI) as well as arms-length transactions (offshore outsourcing). While my theoretical model can incorporate the latter, my data does not include information on arms-length transactions so in the empirical analysis, I restrict offshoring to vertical FDI.

productivity effect causes these firms to expand production and demand more labor - if the subsequent increase in the demand for labor is strong enough, then industry wages could rise.

The theoretical framework in this paper brings together the labor demand effect and the productivity effect to identify the heterogeneous firm-level effects of offshoring. First, firms are heterogeneous in productivity and there is a fixed cost of offshoring so that only the most productive firms choose to offshore ("MNCs"), while the less productive firms choose to source solely from the domestic market ("purely domestic" firms). Second, the productivity effect from offshoring manifests as higher profits-per-domestic worker. Third, workers are homogeneous while search and bargaining in the labor market gives rise to a rent-sharing wage specification. Further, this wage specification endogenizes the outside option of workers and confirms that offshoring lowers this outside option<sup>2</sup>.

The two competing effects on wages produce different outcomes at different firms. Firms who choose to offshore experience a productivity effect, increasing their profits-per-domestic worker, which are then shared with domestic workers. I label this mechanism the productivity plus rent-sharing (PRS) effect. This effect varies by firm and is stronger at more productive firms. Meanwhile, offshoring lowers overall employment in the sector causing the outside option of all workers in the sector to fall - the labor demand effect. At more productive firms, the PRS effect dominates and wages rise, while for less productive firms who are unable to offshore, the negative labor demand effect dominates and wages fall. This model predicts increased wage dispersion across firms in the sector, with most of the wage dispersion occurring at the upper-tail of the wage distribution and little or none occurring at the lower-tail, which is consistent with recent empirical findings. In addition, offshoring increases the competitive position of MNCs relative to purely domestic firms, thereby causing them to gain market share at the latter's expense. Hence, at MNCs, the net effect on employment is ambiguous, with the direct job loss due to offshoring being potentially offset by expansion. However, purely domestic firms

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<sup>2</sup>A priori, I make no assumption about whether this effect is positive or negative. In fact, if the productivity effect is strong enough and MNC firms sufficiently expand, employment in the sector could expand and the outside option could increase. However, in equilibrium, I show this is not possible. Therefore, the labor demand effect is negative in my model and confirms previous predictions of its effect.

contract and shed jobs.

The empirical portion of this paper, using unique firm-level data on US MNCs and their affiliates, tests the above predictions. The methodology uses two episodes in Mexico as exogenous shocks to the cost of offshoring to Mexico for US firms. First, the FDI law of 1993 relaxed limits on foreign ownership of Mexican firms from 49% to 100%. Second, the peso depreciation at the end of 1994 significantly lowered real wages of Mexican workers in dollar terms making Mexico a more attractive platform for offshoring. Figures 2 and 3 depict how offshoring to Mexico by US firms jumped substantially following these events. Comparing treatment firms to control firms<sup>3</sup>, I find that offshoring, profits-per-domestic worker, and average wages increased more for treatment firms during the period 1993-97. Further, these differential changes were statistically significant when compared with the time period 1997-01 for all the same outcome variables. These results offer support for the hypothesis that offshoring, through profits-per-worker, increases within-group (where group is the sector) wage dispersion. Additionally, this analysis finds that while employment decreased at both types of firms, there is no evidence of greater job loss at treatment firms relative to control firms.

## **II - Motivation and Literature**

The trends in offshoring have been increasingly significantly over time and portend even more significant possibilities in the future. For example, the share of total global employment by US MNCs that has been offshored increased from about 4% in 1982 to 12% in 2004 with most of this increase being driven by offshoring to low-income countries<sup>4</sup>.

Furthermore, as technology continues to improve and trading and offshoring costs continue to fall, Blinder (2006) argues that the scope for offshoring is tremendous. He notes that most manufacturing jobs and some jobs in certain service areas such as infor-

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<sup>3</sup>I define the control set as US firms who offshore to Latin American countries but not Mexico as of 1993; treatment set is defined as US firms who offshore to Mexico as of 1993. I go into further discussions on treatment and control in section VIII and also try additional treatment/control groups for robustness.

<sup>4</sup>These figures come from Bureau of Economic Analysis (BEA) data on US MNC firms. The numbers are derived from the fact that employment share of US MNCs based abroad has increased from 20-35% during this period. At the same time, the share of vertical FDI over total FDI has increased from approximately 20-33%. FDI for market access (horizontal) still claims two-thirds of total FDI, but its share has been shrinking over time.

mation, financial, and business and professional services could be offshored, estimating that up to 20-25% of American jobs could be vulnerable. Though I think that Blinder over-estimates the "death of distance", I agree with his larger point that offshoring will play an increasingly important role in the global economy.

Meanwhile, wage inequality within the US and other countries over the last several decades has been rising, concurrent with the aforementioned trends in offshoring. While rising between-group wage inequality - the skill premium - seems to play a majority role, evidence exists that within-group wage inequality also appears to contribute to overall wage inequality. Lemieux (2006) and Autor, Katz, and Kearney (2008) find that residual inequality has increased at the upper-tail (90-50 percentile) of the distribution but have stagnated at the lower-tail (50-10 percentile). Separately, Barth and Lucifora (2006) also find rising within-group inequality within secondary and tertiary educated workers is significant in explaining total wage inequality in European countries from 1983-2003. While some papers have offered a trade-related explanation - see Egger and Kreickemeier (2006), Helpman and Itskhoki (2007) and Helpman, Itskoki, and Redding (2008), and Amiti and Davis (2008) - this paper posits an offshoring-related explanation.

There are numerous other papers that have looked at offshoring and labor market impacts. Bertrand (2004), Karabay and McLaren (2006) examine the effects of trade and offshoring on wage volatility through the effect on wage contracts between firms and workers in a model of risk-sharing under incomplete information. Antras, Garciano, and Rossi-Hansberg (2006) examine offshoring in a matching model with a single technology and heterogeneous workers which allows them to speak to between-group wage inequality and skill premium. Davidson, Matusz, and Shevchenko (2006) use job search to specifically study the impact of offshoring of high-tech jobs. Rodriguez-Clare (2006) considers offshoring in a Ricardian framework to analyze the positive productivity effect and the negative terms of trade effect on wages and welfare. Closer to my work is Mitra and Ranjan (2004) who also use search frictions in a model with heterogeneous firms under offshoring. However, their channel operates at the sectoral-level rather than the firm-level, which is a key contribution of my research<sup>5</sup>.

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<sup>5</sup>Their mechanism works through Stolper-Samuelson type price effects where offshoring raises the rela-

Sections III-V develop the theoretical framework in full detail before and after increased liberalization of offshoring. Section VI describes the data and presents some descriptive statistics. Section VII provides background on the episodes in Mexico, details the empirical methodology, and presents the results. Finally, Section VIII concludes.

### **III - Model**

The focus of the model is on the consequences of new opportunities from offshoring, without considering the full set of feedbacks from abroad.

Consider an economy where all goods are produced with one factor, labor, which is homogeneous.  $L$  units of total labor are split between two sectors,  $X$  and  $Y$ . Sector  $X$  is a homogeneous goods sector that competes under perfect competition in both product and labor markets. The homogeneous good from sector  $X$  can be thought of as the numeraire good, with price  $p_x$  normalized to 1. The production technology in sector  $X$  is expressed as  $Q_x = L_x^\alpha$  where  $0 < \alpha < 1$  means returns to labor are diminishing. The presence of fixed costs ensure zero profits for all firms in this sector. Further, I assume that offshoring possibilities are not available for firms in sector  $X$ .

Sector  $Y$  is a differentiated goods sector that possesses search frictions in the labor market and monopolistic competition in the product market. Firms in sector  $Y$  act in two stages: (1) firms and workers search, match, and bargain over wages; (2) once wages have been set, firms compete with each other as monopolistic competitors in the product market. The production technology in sector  $Y$  incorporates two tasks, type 1 and type 2, in order to make the final good; the type 1 task can be offshored and the type 2 task cannot be offshored. We can think of all workers as being homogeneous ex-ante, but once they are hired, they are randomly placed in type 1 or type 2 tasks. The tasks are combined in a Leontief function such that  $q = \phi \min[\frac{N_1}{1-\bar{\beta}}, \frac{N_2}{\bar{\beta}}]$ , where  $N_1, N_2$  represent the number of workers performing tasks 1 and 2, respectively. Defining  $N_1 = (1 - \bar{\beta})N$  and  $N_2 = \bar{\beta}N$ , the production function simplifies to a linear form,  $q = \phi N$ . In other words,  $\bar{\beta} < 1$  places a technological constraint on offshoring. No technology can exist to allow

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tive price of the good produced with domestic labor, thereby increasing domestic wages.

all activities to overcome distance barriers. For example, certain service activities where face-to-face interaction is highly desirable or even necessary can never be offshored -  $\bar{\beta}$  represents this constraint. Finally, for simplification, sector  $Y$  can import intermediate goods but not trade in final goods.

### **III.A - Labor Market**

Labor is perfectly competitive in sector  $X$  and is paid its marginal product of labor. Further, this sector absorbs any residual labor from sector  $Y$ . Defining the demand for labor/employment in sectors  $X$  and  $Y$  as  $L_x$  and  $L_y$ , respectively:  $L_x = L - L_y$ .

Unlike the labor market in sector  $X$ , the labor market in sector  $Y$  is not perfectly competitive and functions as follows. All workers begin by searching in sector  $Y$  for jobs, knowing that even if they do not find one, they can costlessly move to sector  $X$  and earn  $w_x$ . Then, workers and firms in sector  $Y$  are randomly matched. Temporary unemployment in this sector derives from the fact that the number of searchers ( $L$ ) exceeds the labor demand in the sector ( $L_y$ ). The temporarily unemployed workers in sector  $Y$  move to sector  $X$  and receive wages  $w_x$ . Once a match occurs, a firm and a worker achieve a surplus from agreeing on a wage. For firms, I assume that search costs are prohibitively high such that if an agreement is not reached, the firm must operate with one less domestic worker. On the other hand, the worker's outside option is to move to sector  $X$  and earn  $w_x$ . For simplicity, I assume that the surplus is allocated by a Nash bargaining game, which leads to a rent-sharing wage specification. Empirically, numerous studies have found evidence of rent-sharing at the sectoral and firm-level in many developed countries<sup>6</sup>. Goos and Konings (2006) summarize that the empirical literature on rent-sharing finds an elasticity of rent-sharing between 0.1-0.3 for the US, Canada, UK, and some European countries. The Nash bargaining game between a worker and a firm is as

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<sup>6</sup>Some important papers demonstrating evidence of rent-sharing include Abowd and Lemieux (1993), Blanchflower, Oswald, and Sanfey (1996), and Hildreth and Oswald (1997), who examine Canadian bargaining agreements, a panel of US industries, and a panel of UK firms, respectively. Blanchflower, Oswald, and Sanfey further demonstrate that rent-sharing is present even in industries with low unionization rates, demonstrating that rent-sharing can be motivated from non-union models. Budd and Slaughter (2000) go further and using Canadian labor contracts in manufacturing, find the presence of intra-firm, cross-border rent-sharing. Abowd, Kramarz, and Margolis (1999) suggest that firm specific effects explain about 21-26% of higher wages, with the remaining explained by labor specific effects.

follows:

$$\max_w \theta \ln(w - w_x) + (1 - \theta)[\Pi_{op}(N_d) - \Pi_{op}(N_d - 1)] \quad (1)$$

$\theta \in [0, 1]$  and  $(1 - \theta)$  are the exogenous Nash bargaining parameters of workers and firms, respectively. Also,  $N_d$  is the number of domestic workers at the firm where the number of workers are chosen in the second stage during product market competition. Lastly, if the parties reach a wage agreement, the firm earns operating profits  $\Pi_{op}(N_d)$ , else it earns operating profits  $\Pi_{op}(N_d - 1)$ . Leaving the details to appendix A.1, solving this bargaining game elicits the following rent-sharing wage specification:

$$w = \eta \pi_{op} + w_x \quad (2)$$

where  $\eta = \eta(\theta, \bar{\beta}, \varepsilon_{ld})$ <sup>7</sup>. Since  $\eta$  is a function of exogenous parameters of the model, it is itself also exogenous. Finally,  $\pi_{op} = \frac{\Pi_{op}}{N_d}$  are operating profits-per-domestic worker.

The home country is assumed to be small relative to the foreign supply of labor. Hence, from the perspective of domestic firms, the foreign labor supply is perfectly inelastic and firms face an exogenous foreign wage  $w_f$ <sup>8</sup>, which is sufficiently small<sup>9</sup>.

Having determined wages, firms now compete in the product market under monopolistic competition, which elicits a discussion of consumer demand.

<sup>7</sup>See Abowd and Lemieux (1993) and Estevao and Tevlin (2000) for more a detailed exposition on the relationship between  $\eta$  and  $\theta$ .

<sup>8</sup> $\frac{(1-\bar{\beta})w_f}{\phi}$  can also be thought of as the marginal cost for an outsourced arms-length transaction, without changing any of the implications. Hence, my model is agnostic as to whether the production process stays within the firm (vertical FDI) or is outsourced.

<sup>9</sup>What if foreign wages were not exogenous but rather rent-sharing with foreign workers did exist. If the rent-sharing parameter ( $\eta$ ) were the same between domestic and foreign workers, the main results of the model are unchanged. However, it seems highly unreasonable, given the difference in labor market institutions, that the rent-sharing parameter would be the same for US and foreign labor. Using different rent-sharing parameters for domestic versus foreign workers makes the model intractable. As a possible extension, one could consider other ways of endogenizing foreign wages.

### III.B - Demand

Consumer preferences follow the specification of Melitz and Ottaviano (2007)<sup>10</sup>. In an economy with  $L$  units of labor:

$$Q = U = q_x + \left[ \rho \int_{i \in I} q_i di \right] - \left[ \frac{1}{2} \gamma \int_{i \in I} (q_i)^2 di \right] - \left[ \lambda \left( \int_{i \in I} q_i di \right)^2 \right] \quad (3)$$

with the measure of set  $I$  representing the mass of goods produced in sector  $Y$  and  $q_x$  and  $q_i$  representing the consumption of the homogeneous good and the differentiated good, respectively, by an individual consumer. The parameter  $\rho$  indexes the substitution between differentiated good  $i$  and good  $X$  while  $\lambda$  indexes the substitution between aggregate good  $Y$  and good  $X$ . Lastly,  $\gamma$  indexes the degree of product differentiation amongst the differentiated goods in  $I$ . The quasi-linear form for utility fixes expenditure in sector  $Y$  so that there are no income effects on the consumption of the differentiated goods. Each firm is a monopolist in its own good but faces competition from other goods, which are imperfect substitutes ( $\gamma > 0$ ). Solving the consumer's constrained optimization leads to the following inverse demand function:

$$p_i = \rho - \gamma q_i - \lambda Q_y \quad (4)$$

where  $Q_y$  represents total consumption of aggregate good  $Y$ . Inverting this function gives demand for good  $i$  in this sector:

$$Lq_i = \frac{\rho L}{\lambda M + \gamma} - \frac{L}{\gamma} p_i + \frac{\lambda M}{\lambda M + \gamma} \frac{L}{\gamma} \bar{P}_y \quad (5)$$

where  $M$  is the measure of consumed varieties from the demand side (or the measure of firms from the production side) and  $\bar{P}_y$  is the average price in sector  $Y$  defined as

$$\bar{P}_y = \frac{1}{M} \int_{i \in I} p_i di.$$

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<sup>10</sup>CES preferences imply constant markups, which is unrealistic and leads to some important inconsistencies in my model - profits-per-worker and wages decrease with firm productivity with especially the latter going against empirical evidence. Preferences leading to endogenous markups correct this inconsistency.

Also, define  $p_{max}$  as the price at which demand for a good vanishes:

$$p_{max} = \frac{\gamma\rho}{\lambda M + \gamma} + \frac{\lambda M}{\lambda M + \gamma} \bar{P}_y \quad (6)$$

Any firm which sets prices  $p \geq p_{max}$  earns zero demand and profits.

## IV - Partially Open Economy

### IV.A - Production under Limited Offshoring: Profits and Wages

I consider the benchmark case as one with limited offshoring rather than complete autarky in order to tie the theory closer to the empirical work. The data reveals that given new opportunities, offshoring expands primarily along the intensive margin rather than the extensive margin<sup>11</sup>, which is more consistent with a starting point of limited offshoring<sup>12</sup>.

In sector  $Y$ , there are a continuum of firms, each producing a different good,  $i$ <sup>13</sup>. Production requires only one factor, labor. Following Hopenhayn (1992), firms pay a fixed entry cost ( $f_e$ ) to learn their productivity parameter from distribution  $G(\phi)$ . Then, once they realize their productivity, firms either decide to enter and start production or exit immediately<sup>14</sup>. Since demand is linear, and  $p$  is decreasing in  $\phi$  (shown in appendix A.2(a)), there exists a unique  $\phi^*$  such that  $p(\phi^*) = p_{max}$  and  $\Pi(\phi^*) = 0$ ;  $\phi^*$  serves as a cut-off to partition firms between those who exit ( $\phi < \phi^*$ ) and those who stay in the market ( $\phi \geq \phi^*$ ) and earn non-negative profits. In addition, firms in this sector would like to take advantage of cheaper wages abroad; to do so, they must pay an additional sunk cost,  $f_o$ , that is related to setting up production facilities abroad. Firms share  $f_e$  and  $f_o$  but differ in their productivity levels ( $\phi$ ). Similar to Melitz (2003),  $f_o$  partitions firms

<sup>11</sup>Approximately 94% of increased vertical FDI from the US to Mexico occurred on the intensive margin; 6% on the extensive margin during the 1993-97 period.

<sup>12</sup>If the starting point were complete autarky, then all new offshoring would be along the extensive margin.

<sup>13</sup>Ensuing discussions are from the point of view of an individual firm and so the subscript  $i$  is dropped.

<sup>14</sup>Following Melitz and Ottaviano (2007), I do not model fixed domestic production costs for simplicity. Fixed domestic production costs do not add new insights and in fact obscure the key intuition. Because of the linear demand, low-productive firms will not be able to survive even without fixed costs.

by productivity<sup>15</sup>. Appendix A.3(a) shows the existence of and defines the productivity cut-off  $\phi_o^*$ . The following summarizes the separation of firms:

$$\left\{ \begin{array}{ll} \text{MNC firms:} & \text{if } \phi_o^* < \phi \\ \text{Purely domestic firms:} & \text{if } \phi^* < \phi < \phi_o^* \\ \text{Exiting firms:} & \text{if } \phi < \phi^* \end{array} \right.$$

Next, I define  $\beta$ <sup>16</sup> as the fraction of a firm's employees based abroad and  $1 - \beta$  as the fraction of a firm's employees maintained in the US. To model that offshoring opportunities are only partially open, I assume that in addition to a technological constraint ( $\bar{\beta}$ ), firms also face a foreign regulation constraint,  $\hat{\beta}$ , where  $\hat{\beta} < \bar{\beta}$ <sup>17</sup>. Firms set  $\beta = \min[\hat{\beta}, \bar{\beta}] = \hat{\beta}$ .

Now, total costs can be written as  $TC(q(\phi)) = w(\phi)N(\phi) + f_o = \frac{w(\phi)q(\phi)}{\phi} + f_o$ ; marginal costs are  $c(\phi) = \frac{w(\phi)}{\phi}$ ; where  $w$  are average wages paid by the firm and are:

$$w = \beta w_f + (1 - \beta)w_d \quad (7)$$

where  $w_d$  is the wage paid to US worker and is set according to the rent-sharing wage specification in equation (2). I now solve for key variables,  $\pi_{op}$ ,  $w_d$ ,  $c$  for both MNC firms (superscripted with  $M$ ) and purely domestic firms (superscripted with  $D$ ):

$$\pi_{op}^M = \frac{\phi p - \beta w_f - (1 - \beta)w_x}{(1 - \beta)(1 + \eta)} \quad (8) \quad w_d^M = \frac{\eta \phi p - \eta \beta w_f + (1 - \beta)w_x}{(1 - \beta)(1 + \eta)} \quad (9)$$

$$c_d^M = \frac{\eta \phi p + \beta w_f + (1 - \beta)w_x}{\phi(1 + \eta)} \quad (10)$$

<sup>15</sup>My model is static whereas Melitz (2003) is dynamic. However, the sunk cost  $f_o$  in this model mimics the per-period fixed costs in the Melitz model by partitioning firms along the productivity dimension.

<sup>16</sup> $\beta$  is an endogenous choice variable. However, in this model, since the marginal cost of offshoring is zero, firms would like to offshore as much as possible, setting  $\beta = \bar{\beta}$ . Such a solution is not informative in predicting the extent of offshoring. However, I assume this simplification because the aim of this paper is not to understand the extent of offshoring but rather the ramifications.

<sup>17</sup>This follows closely with the empirical analysis where Mexico's Foreign Investment Law of 1973 prohibited foreign firms from owning more than a 49% stake in Mexican firms.

$$\pi_{op}^D = \frac{\phi p - w_x}{(1 + \eta)} \quad (11)$$

$$c_d^D = \frac{\eta \phi p + w_x}{\phi(1 + \eta)} \quad (13)$$

$$w_d^D = \frac{\eta \phi p + w_x}{(1 + \eta)} \quad (12)$$

Notice that setting  $\beta = 0$  for equations ((8) - (10) gives the equilibrium equations for purely domestic firms. Also, from the above equations, we learn that  $c$  is falling with firm productivity, while  $\pi_{op}$  and  $w_d$  are increasing in firm productivity (see appendix A.2 for proofs). The last feature is consistent with the stylized fact that more productive firms pay higher wages (see Abowd, Kramarz, and Margolis (1999); Brown and Medoff (1989)). Appendix A.2 also shows that  $p$  is falling with firm productivity, while margins ( $\mu = p - c$ ),  $q$ ,  $\Pi_{op}$  are increasing with firm productivity. Now, plugging in equation (5) for demand, the firm solves its maximization problem by setting prices to maximize profits:

$$D(p, v) : -\frac{L}{\gamma}p + q + \frac{L}{\gamma} \left[ \frac{\eta \phi p + w_x}{\phi(1 + \eta)} \right] - q \frac{\eta}{1 + \eta} = 0 \quad (14)$$

Though I cannot explicitly solve for prices in this framework, equation (14) provides an implicit function of  $p$  and a vector ( $v$ ) of other parameters of the model. This implicit function will be crucial in determining how the key firm-level variables in the model respond to offshoring.

## **IV.B - Firm Entry & Exit, Equilibrium in Partly Open Economy**

With respect to the entry and exit of firms in heterogeneous sector  $Y$ , I follow Melitz (2003). Prior to entry, firms are identical and must pay an entry cost  $f_e$  to observe their firm-specific productivity draw from a cumulative distribution  $G(\phi)$  with density  $g(\phi)$  over the support  $[1, \infty)$ . As is common in trade/IO models, I assume a pareto distribution

to parameterize  $G(\phi)$ <sup>18</sup>:

$$G(\phi) = 1 - \left(\frac{1}{\phi}\right)^k \quad g(\phi) = \frac{k}{\phi} \left(\frac{1}{\phi}\right)^k \quad (15)$$

The zero-cutoff profit (ZCP) condition asserts that the profits of the marginal entrant should be zero ( $\pi(\phi^*) = 0$ ). Having defined  $\phi^*$ , the ex-post distribution of productivities of firms in the market is defined as:

$$\varphi(\phi) = \begin{cases} \frac{g(\phi)}{1-G(\phi^*)} = \frac{k}{\phi} \left(\frac{\phi^*}{\phi}\right)^k & \text{if } \phi \geq \phi^* \\ 0 & \text{otherwise} \end{cases}$$

Using the ZCP condition, I would like to solve for  $\bar{\pi} = \pi(\bar{\phi})$ . But first, I need to determine average productivity in sector Y,  $\bar{\phi}$ <sup>19</sup>:

$$\begin{aligned} \bar{\phi} &= \int_{\phi^*}^{\infty} \phi \varphi(\phi) d\phi \\ \bar{\phi} &= \frac{k}{k-1} \phi^* \quad \text{assuming } k > 1 \end{aligned} \quad (16)$$

Next, from equations (5) and (6), I can write  $q = \frac{L}{\gamma}(p_{max} - p)$ , which allows me to express profits as:  $\Pi = q(p - c) = \frac{L}{\gamma}(p_{max} - p)(p - c)$ .

Using this equality and equation (14), I define average sectoral profits:

$$\begin{aligned} \bar{\Pi} &= \Pi(\bar{\phi}) = \Pi\left[\left(\frac{k}{k-1}\right)\phi^*\right] \\ \bar{\Pi}(\phi^*) &= \frac{\frac{L}{\gamma}(p(\phi^*) - p(\bar{\phi}))(\phi^* \frac{k}{k-1} p(\bar{\phi}) - w_x)}{\phi^* \left(\frac{k}{k-1}\right)(1+\eta)} \quad (ZCP) \end{aligned} \quad (17)$$

In addition to the ZCP condition, the equilibrium structure in this sector is defined by another condition. Due to free entry in the differentiated good sector, the expected profits from entry should equal the fixed cost of entry, thereby setting the expected payoffs equal

<sup>18</sup>Axtell (2001) shows that pareto accurately captures the distribution of US firms. Using data from eleven European countries, Del Gatta, Mion, and Ottaviano (2006) also find that "pareto is a fairly good approximation" of the productivity distribution in their dataset.

<sup>19</sup>I implicitly assume that  $\bar{\phi}$  represents a purely domestic firm. Given the pareto distribution of productivities and the empirical fact that the super majority of all firms are purely domestic firms, this assumption is quite appropriate. However, even though the equilibrium is solved under this assumption, none of the main results/predictions would change if  $\bar{\phi}$  represented an MNC firm.

to zero, ex-ante. The FE condition can be written as:

$$\begin{aligned} [1 - G(\phi^*)]\bar{\Pi}(\phi^*) &= f_e \\ \bar{\Pi}(\phi^*) &= f_e(\phi^*)^k \end{aligned} \quad (\text{FE}) \quad (18)$$

Appendix A.4 shows how both the FE and ZCP conditions behave in the  $(\bar{\pi}, \phi^*)$  space. It is straightforward to demonstrate that the FE condition is increasing with  $\phi^*$ . The ZCP is more complicated to analyze but summarizing appendix A.4:

$$\left\{ \begin{array}{ll} \text{ZCP is decreasing in } (\bar{\pi}, \phi^*) \text{ space} & \text{if } 1 < k < 2 \\ \text{ZCP is constant in } (\bar{\pi}, \phi^*) \text{ space} & \text{if } k = 2 \\ \text{ZCP is increasing in } (\bar{\pi}, \phi^*) \text{ space} & \text{if } k > 2 \end{array} \right.$$

Clearly, the first two cases ensure the existence and uniqueness of an equilibrium. In the third case, appendix A.4 shows that the second derivative of the FE condition is positive, while the second derivative of the ZCP condition is negative and further, under fairly innocuous parameter conditions, the FE condition starts below the ZCP. Therefore, regardless of the pareto shape parameter,  $k^{20}$ , the existence and uniqueness of an equilibrium is ensured.

## V - Fully Open Economy

### V.A - Production under Full Offshoring: Profits and Wages

Liberalization is modeled as an exogenous increase in  $\hat{\beta}$  to 1. In other words, the foreign limitations on investment are relaxed, allowing US firms to offshore as much as they would like<sup>21</sup>. This liberalization affects offshoring on both the intensive and extensive margin. First, along the intensive margin, MNCs increase their offshoring to  $\beta = \bar{\beta}$ . Also,  $\phi_o^*$  falls (see appendix A.3(b)) causing previously purely domestic firms to perform

<sup>20</sup>Axtell (2001) estimates a pareto shape parameter of 1.0-1.1 for US firms using various definitions of firm size. Del Gatta, Mion, and Ottaviano (2006) estimate a pareto shape parameter of 1.6-2.4 for their distribution of productivity across 17 industries, pooling over firms in 11 European countries.

<sup>21</sup>In the empirical section, this is captured by the passage of the FDI law of 1993, which allowed maximum foreign ownership of Mexican firms to increase from 49% to 100%.

offshoring along the extensive margin. The intuition behind this mechanism is that because more offshoring is possible now, the gains from entry into offshoring are higher, allowing some new entrants to recover the sunk costs  $f_o$ . However, this paper will focus on the effects through the intensive margin - the data reveals that approximately 94% of the increase in offshoring from 1993-97 from US to Mexico happened along the intensive margin - rather than the extensive margin<sup>22</sup>.

In order to understand the effects of offshoring on wages at the firm-level, refer to the wage specification in equation (2) - offshoring can affect wages through  $\pi_{op}$  and  $w_x$ . Beginning with a discussion of the latter, how does increased offshoring affect the outside option of workers ( $w_x$ )? A priori,  $L_y$  (and therefore  $w_x$ ) could move in either direction under offshoring. There are two general equilibrium considerations: (1) loss in jobs directly due to offshoring; (2) loss or gain in jobs due to industry dynamics. Appendix A.5 demonstrates that, in equilibrium, the outside option ( $w_x$ ) must necessarily fall with offshoring. To understand the intuition behind this, let's assume otherwise - the outside option of workers rises with offshoring. Then, wages of domestic workers would increase at all firms in sector  $Y$ . This would cause average industry profits to fall, which would lower the  $\phi^*$  entry cut-off in equilibrium. On the other hand, less productive firms unambiguously lose profits, in part due to the higher wage costs, and hence would be forced to exit the industry. However, this fact is not consistent with the productivity entry cut-off,  $\phi^*$ , falling. Hence, in equilibrium, it must be that  $w_x$ , the outside option of workers in sector  $Y$ , must fall with offshoring. Finally, I would like to make one additional point here. As discussed in the introduction, previous literature has proposed that offshoring would place downward pressure on wages. By endogenizing the outside option ( $w_x$ ), this model captures this idea, which is something new, I believe, in rent-sharing wage models.

Next, I describe the effects of offshoring on firm-level variables and importantly on wages in the propositions below.

**Proposition 1A:** *For a MNC firm, increased offshoring reduces marginal costs ( $c$ ) and*

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<sup>22</sup>Wages increase at new firms entering into offshoring but the increase could be smaller or larger than that at existing MNCs depending on model parameters.

prices ( $p$ ), while raising margins ( $\mu$ ), and operating profits per domestic worker ( $\pi_{op}$ ). Refer to appendix A.6(a)-(d) for a proof of proposition 1A.

**Proposition 1B:** *There exists a  $\hat{\phi}$  such that if  $\hat{\phi} > \phi_o^*$  then offshoring increases wages for workers at highly productive MNC firms ( $\phi > \hat{\phi}$ ) and decreases wages at lower productive MNC firms ( $\hat{\phi} > \phi > \phi_o^*$ ). If  $\hat{\phi} < \phi_o^*$ , then wages rise for workers at all MNC firms. Refer to appendix A.6(e) for a proof of proposition 1B.*

First, for proposition 1A, offshoring unambiguously reduces costs for the MNC firm in two ways. First, since foreign wages are low, they save on wage costs for offshored jobs. Second, since  $w'_x(\hat{\beta}) < 0$ , the outside option for all domestic workers decreases with offshoring in the sector, and so wage costs to the firm are lowered for this reason as well. The reduction in costs is partly passed on to the consumers in the form of lower prices, but the rest is kept as higher margins ( $\mu$ ) to the firm. Note that  $\pi_{op} = \frac{\phi\mu}{1-\beta}$ . For MNCs, increased offshoring leads to higher  $\mu$  and  $\beta$ , and therefore  $\pi_{op}$  unambiguously increases with offshoring, which I call the productivity effect. Further, higher  $\pi_{op}$  is then shared with the remaining domestic workers; this combined mechanism is the PRS effect.

With respect to proposition 1B, recall equation (2), which details the wage specification as  $w_d = \eta\pi_{op} + w_x$ . Offshoring has two competing effects on the wages of domestic workers remaining at MNC firms. The first effect is the direct effect of a loss in the outside option since  $w'_x(\hat{\beta}) < 0$ . The second effect operates indirectly through the positive PRS effect detailed above. Importantly, the loss in the outside option is the same for all workers in the sector but the magnitude of the PRS effect varies across firms. Which effect dominates? In appendix A.6(d), I demonstrate that the gain in  $\pi_{op}$ , and therefore the PRS effect, is greater at more productive firms. Hence, a  $\hat{\phi}$  is defined such that for domestic workers at MNCs with  $\hat{\phi} < \phi$ , the PRS effect trumps the fall in  $w_x$  and wages rise. On the other hand, for domestic workers at MNCs with  $\phi_o^* < \phi < \hat{\phi}$  the PRS effect is not strong enough and wages fall. However,  $\hat{\phi}$  does not necessarily have to be greater than  $\phi_o^*$ . In fact, if  $\hat{\phi} < \phi_o^*$  then wages rise at all MNC firms.

Next, how does offshoring by MNC firms, affect purely domestic firms and workers

at those firms?

**Proposition 2A:** *Offshoring by MNCs has a positive productivity externality on purely domestic firms, reducing their marginal costs ( $c$ ) and prices ( $p$ ), and raising their margins ( $\mu$ ) and operating profits per domestic worker ( $\pi_{op}$ ). Refer to appendix A.7(a)-(d) for a proof of proposition 2A.*

**Proposition 2B:** *However, offshoring by MNCs reduces wages for workers at purely domestic firms. Refer to appendix A.7(e) for a proof of proposition 2B.*

Regarding proposition 2A, purely domestic firms are themselves unable to offshore, but offshoring by MNCs lowers the outside option ( $w_x$ ) for all domestic workers in the sector. Therefore, costs and prices fall at purely domestic firms, leading to a positive, though small, productivity effect, which raises margins. In order to analyze  $\pi_{op}$ , remember that for domestic firms,  $\pi_{op} = \phi\mu$ . Since margins increase,  $\pi_{op}$  must increase. The question then arises as to whether  $\pi_{op}$  increases enough to offset the fall in the outside option? Appendix A.7(e) demonstrates that the direct negative effect always dominates the small, positive PRS effect for workers at purely domestic firms and their wages decrease unambiguously.

Summarizing, domestic workers at both MNCs and purely domestic firms face competing effects from offshoring: (1) a sector-level negative labor demand effect due to a lower outside option; (2) a firm-level positive PRS effect from sharing in a higher  $\pi_{op}$ . The positive PRS effect can dominate at firms who offshore and the labor demand effect dominates at firms who do not offshore, summarized by proposition 3 below:

**Proposition 3:** *Separate firms into three groups: (1) MNCs where  $\hat{\phi} < \phi$ ; (2) MNCs where  $\phi_o^* < \phi < \hat{\phi}$  - if  $\phi_o^* < \hat{\phi}$ ; (3) Purely domestic firms where  $\phi_2^* < \phi < \phi_o^*$ . Then, wages of workers at firms in group 1 rise; if group 2 exists, then wages of workers in this group fall; wages of workers at firms in group 3 fall most. Therefore, offshoring raises the wages at firms who offshore relative to firms who do not, leading to across-firm, within-group wage inequality.*

This is a main prediction of the model and follows directly from propositions 1B and 2B. See figures 1 and 2 for a graphical version of proposition 3. Hence, wages rise at firms who offshore relative to ones who do not, leading to wages diverging in the heterogeneous good sector across firms. Though recent research has revised downwards the importance of within-group inequality for overall wage inequality, its significance is still present if one considers different parts of the wage distribution separately. Lemieux (2006) and Autor, Katz, and Kearney (2008) both document that even controlling for labor composition effects, within-group wage inequality is present and significant at the upper-tail of the wage distribution. In fact, within-group wage inequality comparing 90-50 percentiles has increased markedly over the last few decades while stagnating or even slightly falling comparing 50-10 percentiles. From proposition 3 and figures 1 and 2, we see that this model predicts increases in within-group wage inequality at the upper-tail of the wage distribution and stagnation at the lower-tail, consistent with the empirical findings. Further, this paper offers an explanation that is consistent with the fact that the observed increase in within-group wage inequality has been parallel to the recent surge in intermediate goods trade.

Next, offshoring by MNCs impose an additional externality on purely domestic firms in the form of a negative "business-stealing" effect and is captured by the following proposition:

***Proposition 4: Offshoring by MNCs leads to a re-allocation of production and labor from purely domestic firms to MNC firms. The net effect of offshoring on employment at MNCs is ambiguous. However, employment at purely domestic firms fall. Refer to appendix A.6(f), A.7(f) for a proof of proposition 4.***

From propositions 1(a) and 2(a), offshoring by MNCs enable both MNCs and purely domestic firms to lower costs and prices. However, since MNCs are able to lower costs further, they are able to lower prices further, essentially gaining a competitive advantage relative to their purely domestic competitors. Their increased competitiveness leads to a shift in quantity and market share towards MNC firms. Also, since labor demand at

a firm is proportional to quantity, labor is also re-allocated from purely domestic firms towards MNCs and therefore employment clearly falls at purely domestic firms. The effect on employment at MNCs is ambiguous though as the employment gain due to expansion is offset by the direct loss of jobs due to offshoring.

## **V.B - Firm Entry & Exit under Offshoring**

To analyze the move from the limited offshoring equilibrium to the full offshoring equilibrium, refer back to the ZCP and FE conditions. While the FE condition remains unchanged, the ZCP condition is affected by offshoring. Appendix A.8 demonstrates that the ZCP curve must shift up in response to increased offshoring leading to a higher  $\phi^*$  and higher  $\bar{\pi}$  in the offshoring equilibrium<sup>23</sup>. Now, let the cutoff productivity under limited offshoring be denoted as  $\phi_a^*$ . Then, firms with productivity  $\phi_a^* < \phi < \phi^*$ , must exit the industry, which indicates that for these firms, the negative business-stealing effect dominates the positive productivity effect and hence their profits fall sufficiently to drive them out of business<sup>24</sup>.

Summarizing, firms who offshore increase their productivity and competitiveness (captured by relative prices of these firms falling) as compared to firms who do not offshore, therefore expanding at the latter's expense. Meanwhile, firms who do not offshore experience a loss in relative competitiveness, witness a fall in demand and profits and hence must contract or even exit the industry.

## **V.C - Aggregates under Offshoring**

Average prices in sector Y ( $\bar{P}_y$ ) decrease with offshoring for two reasons: (1) prices decrease at each firm - though they fall more at MNCs than at purely domestic firms,

<sup>23</sup>For confirmation, note that if  $\phi^*$  increases, it must be true that average industry prices ( $\bar{P}_y$ ) must fall (every firm lowers prices under offshoring and the highest pricing firms exit). Then, equation (6) reveals that  $p_{max}$  must fall and hence again, we get that  $\phi^*$  must rise in equilibrium (refer to appendix A.9 for more discussions on this).

<sup>24</sup>Note, however, for the firm with productivity ( $\bar{\phi}$ ), profits rise and hence it must be that the productivity effect dominated the business-stealing effect in its case. Defining  $\phi_c$  such that the productivity effect and business-stealing effects exactly offset each other for a firm with productivity  $\phi_c$ , it must be that  $\bar{\phi} > \phi_c$ . Additional notes on industry dynamics can be found in appendix A.9.

they still fall at all firms; (2) the firms with the highest prices (least productive firms) exit the market. Average productivity increases since the least productive firms exit the industry following offshoring. As argued above, average industry profitability has increased. Next, to balance trade, I simply assume that the intermediate inputs/foreign wages are paid for in terms of the homogeneous good  $X$ . Hence, re-writing the labor market clearing condition gives:

$$L = L_{xd} + L_{xe} + L_y \quad (19)$$

where  $d, e$  denote labor used in sector  $X$  for domestic consumption and exports, respectively. Since  $w_x$  falls with offshoring and  $w_x = \alpha L_{xd}^{\alpha-1}$ , it must be that  $L_{xd}$  rises with offshoring. Further, exports and hence  $L_{xe}$  must also rise to pay for offshoring. Then, from the labor market clearing condition above, this leads to the following conclusion:

**Proposition 5: *Employment in sector  $Y$  ( $L_y$ ) falls with offshoring.***

Empirically, this is supported by evidence from Harrison and McMillan (2006), who, using the same BEA data on US MNCs, find that vertical FDI lowers the demand for labor in that sector. Additionally, Amiti and Wei (2006b) also find that offshoring has a small, negative effect on domestic employment when industries are finely disaggregated. Continuing, I write  $L_y$  in the following way:

$$L_y = \int_{\phi^*}^{\phi_x^*} \frac{q(\phi)}{\phi} d\phi + (1 - \beta) \int_{\phi_x^*}^{\infty} \frac{q(\phi)}{\phi} d\phi \quad (20)$$

where the first term represents employment at purely domestic firms in sector  $Y$  and the second term represents employment at MNCs in sector  $Y$ . Now, the effects of offshoring can be broken down into two main channels. The first is the direct effect of the loss of offshored jobs at MNCs - represented by a rise in  $\beta$ , in the second term above. The second channel, as we saw in proposition 4b, operates through a re-allocation of labor from less productive to more productive firms. In equation (20) this re-allocation comprises of four effects: (1) a fall in  $q(\phi)$  in the first term (contraction by purely domestic firms), (2)

a rise in  $\phi^*$  in the first term (exit of least productive firms), (3) a fall in  $\phi_o^*$  (new entrants becoming MNCs), and (4) a rise in  $q(\phi)$  in the second term (expansion by MNCs). The first two effects have negative implications on employment in sector  $Y$ , while the latter two effects have a positive implication on employment in sector  $Y$ . However it must be that the negative effects dominate the positive effects to reach our previous conclusion that employment in sector  $Y$  falls. Now, let's turn to the data to test propositions 3 and 4, the main predictions from the model.

## **VI - Data**

The primary data source for this paper comes from the Bureau of Economic Analysis (BEA) of the US department of Commerce. The BEA collects confidential data on the activities of US MNCs, defined as the combination of a single US entity (parent) with direct investment to at least one foreign enterprise (foreign affiliate). The BEA data is the most comprehensive data available for US-based MNCs and their foreign affiliates and contains detailed financial and operating numbers for the years 1982-2004<sup>25</sup>.

I begin by constructing a balanced panel over the years 1993-1997 and 1993-2001. First, these panels only include majority-owned affiliates since data on minority-owned affiliates is less comprehensive. Second, though the universe contains both US parent manufacturing and services firms, my sample is restricted to parent manufacturing firms - defined by SIC codes 200-399 - as data on services offshoring is likely less reliable. Third, a concordance between NAICS and SIC codes allows me to handle the shift from SIC to NAICS codes for industry classification from 1997 onwards. Fourth, I restrict my sample even further to parent firms who only have affiliates in developing countries since the motivations for FDI to developed countries can be quite different - for example, a bigger share of FDI to developed countries is horizontal FDI. A major strength of the BEA data is that it allows for more precise measurement of vertical FDI. Most datasets only capture total FDI by a firm, making it difficult to distinguish between FDI for market access (horizontal) versus vertical FDI. The BEA dataset contains information on intermediate trade

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<sup>25</sup>See Bureau of Economic Analysis, March 1999, for a thorough description of definitions and survey methodologies used by the BEA.

and sales among affiliates and from affiliates to non-affiliates. Hence, I define vertical FDI as the sum of the following three variables: (1) sales from foreign affiliate to US parent; (2) sales from foreign affiliate to other local affiliates in the foreign country; (3) sales from foreign affiliates to other affiliates in other foreign countries. Then, by aggregating over all affiliates, I am able to capture the amount of intermediate trade for a US parent firm. In constructing this measure, I am assuming that trade amongst affiliates and the parent is part of the vertical production process while trade to non-affiliated customers is part of horizontal FDI<sup>26</sup>. The number of observations (parent US firms) for 1989-2001 is 34,966 US firms or about 2,300 per year. For manufacturing, there are about 14,882 US firms or approximately 1,000 per year. Key firm-level variables of interest are sales, employment, vertical FDI, R&D expenditures, total employment compensation, and operating profits. Variable definitions are described in appendix A.10.

## **VII - Estimation**

### **VII.A - Background and Empirical Methodology**

To test the main predictions from the model, I use events in Mexico as exogenous shock to the costs of offshoring to Mexico. First, the 1993 Foreign Investment Law was passed in December of 1993, which was tied to NAFTA. Mexico's attitude towards foreign investment has historically been one of caution and weariness. Prior to 1973, there was no investment law in Mexico; rather, rules were decreed on a case-by-case basis by the executive branch. In 1973, a Foreign Investment Law was enacted to establish a uniform, comprehensive code, which turned out to be strongly anti-foreign. Among other measures, the 1973 FIL limited foreign companies to a maximum of 49% ownership in Mexican enterprises, reserved certain activities exclusively for the Mexican government and/or domestic investors, and required approval from the Foreign Investment Commission (FIC) on foreign investment into Mexico adding arbitrariness to the process. During the late 1980s, as the Mexican economy was liberalizing in many areas, the Salinas gov-

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<sup>26</sup>The share of vertical FDI over total FDI was approximately 20% in 1982, rising to 35% in 2004.

ernment realized the importance of foreign investment and passed a 1989 regulation on the 1973 FLI, making it easier for foreign ownership in Mexico. However, the 1989 regulation had little credibility behind it as the Mexican Supreme Court could have deemed it unconstitutional<sup>27</sup>. On the other hand, the 1993 FIL, enacted by the legislature was more legally binding. Further, it was requisite reform for Mexico's participation in NAFTA and hence interestingly, the passage of NAFTA served more as a credibility device than for particular reforms itself. The 1993 FIL liberalized many aspects of the previous Mexican FIL, including, importantly the allowance that foreign firms could own 100% of Mexican enterprises. Together with NAFTA they signaled credibly to the international business community that Mexico was open for foreign investment.

Additionally, the Mexican peso crisis at the end of 1994 also would have impacted foreign investment into Mexico. On December 22, 1994 the peso fell by approximately 25% in relation to the US dollar, and continued falling for several months for a total fall of nearly 60%. This significant depreciation lowered the cost of Mexican labor in dollar terms. Verhoogen (2008) states the average wage for a male full-time worker with nine years of education fell from approximately \$1.50 per hour to \$0.90 per hour from 1994 to 1995. Though there are a variety of theories regarding what precipitated the depreciation, it was ostensibly unexpected as the black market and official exchange rates coincided before and after - see Verhoogen 2008.

From figures 3 and 4, we see that these two episodes elicited a strong increase in vertical FDI through Mexico for US manufacturing MNCs. The first figure depicts that total vertical FDI to Mexico jumped noticeably from 1995-97. The second figure demonstrates an even sharper increase in the share of vertical FDI to Mexico of total global sales of US parent firms from 1995-96. Hence, I consider the period 1993-97 to examine the effects of the two episodes on US parent firm-level variables.

The theoretical model suggests that wages would diverge across firms who would have been able to take advantage of offshoring opportunities to Mexico, and firms who were unable. The model further indicates that firms who already have a presence in Mexico (that is, have already paid the sunk costs of entry) are more likely to be able

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<sup>27</sup>See Uriarte (1995).

to take advantage of new offshoring opportunities. This is borne out by the data. Approximately 94% of the increase in offshoring from 1993-97 occurred along the intensive margin - increase in offshoring by firms already offshoring to Mexico. Only 6% was due to the extensive margin - the entry of new firms offshoring to Mexico. Hence, to test the empirical prediction on wages, I separate firms into treatment and control groups. The treatment group is defined as firms who have a presence in Mexico at the beginning of the period and may or may not offshore to other countries in Latin America. Then, the control group is defined as firms who offshore to other countries in Latin America at the beginning of the period, but do not offshore to Mexico. Further, I am using firms who offshore to other countries in Latin America as my comparison group as they are closest in geography, income status, language, etc. Table 1 provides summary statistics for the treatment and control groups as of the beginning of the period. From table 1, we see that treatment firms on average are larger than control firms, which is an issue addressed in the next section. Beginning with the estimation equation in levels:

$$y_{ijt} = \beta_0 + \beta_1 Treatment_{ij} * Post_t + \beta_2 Post_t + \beta_3 Treatment_{ij} + \gamma_j * Post_t + \epsilon_{ijt} \quad (21)$$

where  $i$ ,  $j$ , and  $t$  index firms, industries, and time respectively;  $y_{ij}$  is one of the outcome variables;  $Treatment_{ijt}$  is a dummy variable, turned on if the firm is in the treatment group and turned off when the firm is in the control group;  $Post_t$  is a dummy variable turned on if the year is 1997 and turned off if the year is 1993;  $\gamma_j * Post_t$  captures industry trends over time; and  $\epsilon_{ijt}$  is a mean-zero disturbance. Differencing the above equation between 1993 and 1997 gives the following equation:

$$\Delta y_{ij} = \beta_2 + \beta_1 Treatment_{ij} + \gamma_j + \epsilon_{ij} \quad (22)$$

Equation (22) is the main estimating equation. The outcome variables of interest are vertical FDI share to Mexico, operating profits-per-US worker, average wages, and employment at the US parent firm.

## **VII.B - Main Results**

The results for equation (22) are displayed in table 2, row 1, columns 1-4, which show that estimates for  $\beta_1$  are statistically significant at least at the 10% level for all of the outcome variables except log employment. For example, vertical FDI share of sales rose 0.8% more for treatment firms than for control firms during the 1993-97 time period, confirming that US firms already with a presence in Mexico are better able to take advantage of new offshoring opportunities to Mexico. Further, columns (2) - (4) indicate that operating profits-per-US worker and average wages increased 7.8% and 7.4%, respectively, more for treatment firms than control firms with the magnitudes indicating economic significance. The 7.4% change in wages between treatment and control firms can be separated into approximately a 3% gain by treatment firms and a 3% loss by control firms<sup>28</sup>. Interestingly, there is no statistical difference between the change in employment at treatment firms versus control firms. Separately, both treatment and control firms lost around 2-3% employment over the 1993-97 period. This is consistent with the theoretical prediction that employment would fall at non-offshoring firms; the theory was ambiguous about the prediction on employment at offshoring firms. Hence, these initial results confirm the two main predictions from the model: (1) wages increase at firms who can take advantage of offshoring opportunities relative to ones who cannot; (2) employment loss is no greater in the former relative to the latter.

## **VII.C - Robustness Analyses/Alternative Hypotheses**

In this section, I strengthen the main findings with robustness checks and testing against alternate hypotheses. First, the above analysis uses parent firms offshoring to Latin America but not to Mexico as the comparison group. To strengthen the analysis, I consider an additional comparison group: parent firms who offshore to other countries

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<sup>28</sup>For two reasons, the results here could even be understating the effect of offshoring on wages. First, this analysis considers only vertical FDI to Mexico. Despite Mexico's importance as a source of offshoring, it still constitutes only about 5% of total vertical FDI by US MNCs. Second, as mentioned previously, offshoring is defined by both outsourcing and vertical FDI. However, in this empirical analysis, only vertical FDI is captured as data on outsourcing is not available; hence, the effects could be even larger if outsourcing is also taken into account.

at the same income level<sup>29</sup> as Mexico but not to Mexico. The results using this additional comparison group are provided in table 2, row (2), where the coefficients for  $\beta_1$  are quite similar to row (1) and hence confirm those results.

Another concern could arise from the difference in treatment and control firms observed in table 1 - treatment firms are larger than control firms by sales, employees, and R&D. It is realistic to expect that bigger firms could react to shocks differently and hence estimated coefficients could be biased. Further, Mexico's unique proximity to the United States could caused treatment firms to respond differently to shocks than control firms, again biasing the the results. To handle these concerns, I compare results from the 1993-97 period to an adjacent period (1997-01) that did not witness exogenous shocks to offshoring. Comparing the coefficients across the two periods can purge any differential trends between the treatment and control groups. This leads essentially to a triple differences strategy captured by the following equation:

$$\Delta y_{ijt} = \beta_0 + \beta_1 Treatment_{ij} * Period_t + \beta_2 Treatment_{ij} + \beta_3 Period_t + \gamma_j + \varepsilon_{ijt} \quad (23)$$

where  $Treatment_{ijt}$  is the same as before;  $Period_t$  is dummy variable taking the value of 0 for the 1993-97 period and 1 for the 97-01 period. Table 3 presents the estimation results for equation (24). A negative coefficient on the interaction term reveals that  $\beta_{93-97}$  is larger than  $\beta_{97-01}$  implying that treatment firms witnessed a greater increase in outcome variables compared to control firms in the 1993-97 period versus the 1997-01 period. The results using comparison group (1) indicate that the estimates for  $\beta_2$  are negative and statistically significant for all of the outcome variables. In particular, we can interpret the results in the following way: operating profits-per-US worker and average wages increased 11.5% and 14.5% more for treatment firms than control firms during the 1993-97 period versus the 1997-01 period. The results are very similar using control group (2) though the estimate for  $\beta_2$  in column (2) is slightly outside the 90% confidence interval. Summarizing, table 3 indicates that  $\beta_{93-97} > \beta_{97-01}$  implying that the FDI Law and the peso crisis caused differential outcomes in the 1993-97 period between treatment and

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<sup>29</sup>Country income levels as defined by the World Bank.

control firms that was greater than generic differences in background trends.

An alternate story based on skill composition could easily be posed for offshoring increasing average firm wages. Feenstra and Hanson (1996) posited that offshoring of jobs from the North to the South would increase the skill composition of workers in the North as the relatively least-skilled jobs would be sent abroad. Continuing their logic, offshoring could lead to higher average wages at the parent firm simply because the cheapest (least-skilled) jobs have been offshored. Hence, even if wages increase from offshoring, how to separate the PRS effect from a simpler selection story? Since the BEA dataset does not contain information on the skill composition of employees at the parent firm, I instead construct a firm-level variable in the following way. From the CPS March Census, I am able to gather skill compositions at the industry level over time. Then in the BEA data, I am able to identify the top eight product (industry) categories for each parent firm. Combining these pieces, I derive a weighted average skill composition variable for each US parent firm (see appendix A.10). From column (5) of table 1, we see that skill composition also increased more for treatment firms than for control firms under both comparison groups, demonstrating that the skill composition story is also valid.

Thus far, the evidence indicates that offshoring caused wages to diverge at the firm-level for two reasons. First, offshoring increased operating profits-per-US worker; then under an assumption of rent-sharing, wages increased, offering evidence for the PRS channel proposed in this paper. Second, the increase in the labor skill composition indicates that the least-skilled jobs were offshored, which would mechanically increase average wages at the firm. To convince the reader of the presence of the PRS effect, I now offer several pieces of further suggestive evidence. First, a few back of the envelope calculations provide further insight into these two effects. Using a rent-sharing elasticity range of 0.1-0.3 from the literature, we can deduce that the PRS effect contributed about 10-30% of the overall wage dispersion of 7.4%<sup>30</sup>. Also, we can determine how big the labor compositional change would have to be in order to entirely explain the 7.4% divergence in wages. From table 1, we see that the average skilled/unskilled labor ratio for a treatment firm is nearly 2.0 in 1993. This ratio would have to rise to about 2.6 in 1997,

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<sup>30</sup>Show calculations.

in order for changes in skill composition to explain the entire 7.4% divergence in wages between treatment and control firms<sup>31</sup>. However, only three<sup>32</sup> manufacturing industries out of eighty-two even had a skill/unskilled labor ratio over 2.6 in 1997, making it highly implausible that skill compositional changes alone could explain the entire divergence in wages.

Recalling equation (2), the PRS effect should be stronger in industries with higher rent-sharing. Hence, I extend equation (22):

$$\Delta w_{ij} = \beta_0 + \beta_1 Treatment_{ij} + \beta_2 Treatment_{ij} * RS_j + \gamma_j + \varepsilon_{ij} \quad (24)$$

where  $RS_j$  captures the extent of rent-sharing in industry  $j$ . A positive and significant estimate for  $\beta_2$  would indicate that wages increased more for treatment firms versus control firms in industries with a higher-degree of rent-sharing. To estimate rent-sharing for industries, I use CPS data from 1993 and regress individuals' wages on a host of observable characteristics and industry dummies. These observable characteristics include state, gender, marital status, age, age-squared, occupation type, and years of schooling<sup>33</sup>. Taking the coefficients on the industry dummies as a measure of rent-sharing, I then estimate the above equation and display the results in table 3. These results indicate that the estimation for  $\beta_2$  from the equation above is positive and statistically significant, under both comparison groups, giving further support for the PRS hypothesis put forth in this paper.

Finally, an alternate explanation based on transfer pricing could be confounding the results. For example, if corporate tax rates were falling in Mexico relative to the United States, then foreign affiliates could charge the US parent firm higher prices for intermediate inputs in order to reduce the firm's overall tax burden. Such a tax/transfer pricing story would show up as increased offshoring in my calculations, but without any implications for productivity gains; rather it would merely reflect changes in book-keeping.

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<sup>31</sup>Conservatively assumes a 2:1 ratio for skilled/unskilled wages during the mid 90s, and the fact that approximately half of the divergence is attributed to a rise in wages at treatment firms (the other half is due to a fall in wages at control firms).

<sup>32</sup>The three industries were drug, computer, and missiles and space vehicles manufacturing.

<sup>33</sup>The observations are weighted based on a sample weighting metric provided by the CPS.

However, corporate tax rates in Mexico remain unchanged during the 1993-97 period. Further, state corporate tax rates in the United States remain unchanged or even fell during this period with the only exception being Vermont<sup>34</sup>. Hence, its unlikely that corporate tax rates could be leading to changes in transfer pricing to the US parent firm. Additionally, corporate tax rates in most of the rest of the world either remain unchanged or even fell, negating the notion that transfer pricing could be in effect from Mexican affiliates to other foreign country affiliates of the firm.

## **VIII - Conclusion**

This paper develops a framework to understand the firm-level effects of offshoring, thereby helping to identify the winner and losers. The model predicts that firms who offshore experience productivity gains and therefore average wages increase at these firms relative to those who do not offshore. Furthermore, while some jobs are lost directly due to offshoring, the productivity gains allows these firms to expand and demand more labor, thereby netting an ambiguous effect on employment. On the other hand, productivity benefits do not accrue significantly to firms who do not offshore, and rather wages fall as the outside of option of workers in the sector falls. Also, these firms become relatively less competitive and hence need to contract or even exit the market entirely, predicting employment loss at these firms.

Using micro-level data from the BEA, this paper utilizes two episodes in Mexico - the FDI Law of 1993 and the Mexican peso crisis - to offer empirical evidence supportive of the above theoretical predictions. The findings suggest that profits-per-domestic worker and average wages increased more for firms better positioned to offshore to Mexico during the 1993-97 period. Furthermore, this differential change was greater than an adjacent period (1997-01) without exogenous shocks to offshoring costs. In addition, the differential change was larger in industries with larger rent-sharing, mitigating concerns that wages could be increasing entirely due to compositional changes in labor from offshoring. Secondly, the mechanism and evidence offered in this paper also suggests a

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<sup>34</sup>State and country corporate tax data reflect the top tax rate and come from the University of Michigan's World Tax Database.

channel through which within-group (sector) wage inequality could be increasing.

The findings in this paper challenge previous views that offshoring most negatively effect wages and employment at firms which offshore. Rather, average wages actually increase at these firms, especially relative to firms unable to offshore. On the other hand, wages and employment fall at firms unable to offshore, due to a relative loss in productivity and competitiveness compared to offshoring firms. From a policy standpoint, offshoring should be viewed as a technology, enhancing productivity and competitiveness. Extrapolating the findings suggests that attempts to hinder offshoring could hamper the productivity and competitiveness of US firms vis-a-vis their global competitors, negatively affecting domestic wages and employment in the long term.

Finally, to conclude, I believe that the model introduced in this paper could spawn further interesting research. First, the model could be extended by considering more than one factor. For example, considering heterogeneous workers would provide implications for both between-group effects as well as within-group effects. Also, adding capital to the mix would provide interesting implications for the changes in returns to capital versus labor in a context of offshoring. Another direction would be to combine offshoring with trade to consider the combined and/or competing effects. Finally, one could also endogenize foreign wages and consider the full set of general equilibrium feedback effects from abroad, to perform a welfare analysis of offshoring.

## Appendix A.1

In order to solve equation (1), we need to know  $\Pi'_{op}(w)$ .

(a) Regarding the former, in the wage bargaining literature, goods markets are generally perfect and hence  $\Pi'(w) = -N_d$ . However, under monopolistic competition, prices are also endogeneously determined. However, even under monopolistic competition, using the first order condition from the firms's second stage maximization problem in the product market and the envelop theorem,  $\Pi'_{op}(w) = -N_d$ .

Solving a general form a firm's optimization problem under monopolistic competition:

$$\max_p pq(p) - c(q(p), w) \quad (25)$$

where

$$\begin{aligned} c(q(p), w) &= wN(q) \\ \frac{\partial c(q(p), w)}{\partial w} &= N \end{aligned}$$

Take the first order condition for (25), we get:

$$pq'(p) + q(p) - \frac{\partial c(q(p), w)}{\partial q} q'(p) = 0 \quad (26)$$

Now, to find  $\Pi'(w)$ , note that  $p^*$  below is the solution to the FOC above:

$$\Pi'_{op}(w) = \frac{\partial p^*}{\partial w} [p^* q'(p^*) + q(p^*) - \frac{\partial c(q(p^*), w)}{\partial q} q'(p^*)] - \frac{\partial c(q(p^*), w)}{\partial w}$$

The term in brackets above is the same as equation (26) and hence from the envelope theorem:

$$\Pi'_{op}(w) = -\frac{\partial c(q(p^*), w)}{\partial w} = -N = -\frac{N_d}{1 - \beta} \quad (27)$$

(b) Next, the firm's surplus from equation (1) becomes:

$$\Pi_{op}(N_d) - \Pi_{op}(N_d - 1) = \frac{\phi(p - c)}{1 - \beta} = \frac{\Pi_{op}(N_d)}{N_d} = \pi_{op}$$

reducing equation (1) to:

$$\max_w \theta \ln(w - w_x) + (1 - \theta)(\pi_{op})$$

Deriving the first order condition of this nash bargaining problem with respect to  $w$ , using (27), and linearizing  $w_x$  around  $w$  gives the following solution:

$$w = \eta\pi_{op} + w_x \quad (28)$$

where  $\eta = \eta(\theta, \bar{\beta}, \varepsilon_{ld})$  is a function of exogenous model parameters and hence itself is exogenous.

## Appendix A.2

Want to 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)  $\frac{d\pi_{op}}{d\phi} > 0$ ; (g)  $\frac{dw}{d\phi} > 0$ .

(a) Show that  $\frac{dp}{d\phi} > 0$ :

To solve for  $\frac{dp}{d\phi}$ , remember the function  $D(p, \phi)$  - equation (14) - which implicitly solves the optimal price for the firm:

$$D(p, \phi) : -\frac{L}{\gamma}p + q + \frac{L}{\gamma} \left[ \frac{\eta\phi p + w_x}{\phi(1 + \eta)} \right] - q \frac{\eta}{1 + \eta} = 0$$

From the implicit function theorem, we know that  $\frac{dp}{d\phi} = -\frac{\frac{\partial D()}{\partial \phi}}{\frac{\partial D()}{\partial p}}$ :

$$\begin{aligned}\frac{\partial D()}{\partial \phi} &= \frac{L}{\gamma} \left[ \frac{w_x}{\phi^2(1+\eta)} \right] \\ \frac{\partial D()}{\partial p} &= -\frac{L}{\gamma} \frac{2}{(1+\eta)} \\ \frac{dp}{d\phi} &= -\left[ \frac{w_x}{2\phi^2} \right] < 0\end{aligned}$$

(b) Show that  $\frac{dc}{d\phi} > 0$ :

Remember that marginal costs =  $\frac{w}{\phi} = \frac{\eta\phi p + w_x}{\phi(1+\eta)}$ . Differentiating with respect to  $\phi$  and plugging in for  $\frac{dp}{d\phi} > 0$  gives:

$$\frac{dc}{d\phi} = -\frac{[w_x](2+\eta)}{2\phi^2(1+\eta)} < 0$$

Hence, so far, we have shown that wages are higher at more productive firms, but marginal costs and prices are lower at more productivity firms.

(c) Show that  $\frac{d\mu}{d\phi} > 0$ :

It is straightforward to show that  $\frac{dp}{d\phi} > \frac{dc}{d\phi}$ , which means that  $\frac{d\mu}{d\phi} > 0$ , indicating that margins are higher at more productive firms.

(d) Show that  $\frac{dq}{d\phi} > 0$ :

Taking the derivative of equation (5) with respect to  $\phi$  and again plugging in for  $\frac{dp}{d\phi} > 0$ :

$$\begin{aligned}\frac{dq}{d\phi} &= -\frac{L}{\gamma} \frac{dp}{d\phi} \\ \frac{dq}{d\phi} &= \frac{L}{\gamma} \frac{w_x}{2\phi^2} > 0\end{aligned}$$

(e) Show that  $\frac{d\Pi}{d\phi} > 0$ :

$\Pi = q * \mu - f$ . Since  $\frac{dq}{d\phi} > 0$  and  $\frac{d\mu}{d\phi} > 0$  from above, then clearly  $\frac{d\Pi}{d\phi} > 0$ , meaning that profits are increasing in firm productivity.

(f) Show that  $\frac{d\pi_{op}}{d\phi} > 0$ :

Taking the derivative of equation (11) with respect to  $\phi$  and substituting in for  $\frac{dp}{d\phi} > 0$

gives:

$$\frac{d\pi_{op}}{d\phi} = \frac{p + \phi \frac{dp}{d\phi}}{1 + \eta}$$

$$\frac{d\pi_{op}}{d\phi} = \frac{2\phi p - w_x}{2\phi(1 + \eta)} > 0$$

To see why the numerator in the above expression must be positive, refer to equation (11), the equilibrium solution for  $\pi_{op}$ . Since  $\pi_{op}$  must be positive in equilibrium, the expressions  $(\phi p - w_x)$  must be positive and so the numerator of the expression above must also be positive.

(g) Show that  $\frac{dw}{d\phi} > 0$ :

Taking the derivative of equation (??) with respect to  $\phi$  and using the result from part (f) gives:

$$\frac{dw}{d\phi} = \eta \frac{d\pi_{op}}{d\phi} > 0$$

### Appendix A.3

(a) Show the existence and define  $\phi_o^*$ :

The sunk costs of offshoring,  $f_o$ , pin down a productivity cut-off,  $\phi_o^*$ , such that firms with  $\phi > \phi_o^*$  are able to offshore and firms with  $\phi < \phi_o^*$  are unable to offshore. If such a cut-off were to exist, then the marginal entrant must be indifferent between offshoring and not offshoring. To show existence of a cut-off, I first would like to demonstrate that offshoring allows a firm to pretend that it is a more productive (hence the notion of a productivity effect). More specifically, I will show that offshoring allows any firm to pretend it has a productivity  $\tilde{\phi} > \phi$  even though its actual productivity is still  $\phi$ . We can find  $\tilde{\phi}$  by setting  $c(\tilde{\phi}) = c(\phi)$ :

$$\eta \tilde{\phi} p(\tilde{\phi}) + \beta w_f + (1 - \beta) w_x = \eta \phi p(\phi) + w_x \quad (29)$$

Since  $w_f \ll w_x$ , it must be that:

$$\beta w_f + (1 - \beta)w_x < w_x \quad (30)$$

which then leads to:

$$\tilde{\phi}p(\tilde{\phi}) > \phi p(\phi) \quad (31)$$

Now, taking the derivative of  $\phi p(\phi)$  with respect to  $\phi$ , and substituting for  $\frac{dp}{d\phi}$  from appendix A.2(a), we get: which then leads to:

$$\frac{d[\phi p(\phi)]}{d\phi} = \frac{2\phi p - w_x}{2\phi} > 0$$

We know its increasing in  $\phi$  because the numerator on the right-hand-side is greater than the numerator from equation (12), which itself is positive. Hence, it must be that  $\tilde{\phi} > \phi$ . Hence, offshoring allows any firm with productivity  $\phi$  to pretend to be of higher productivity  $\tilde{\phi}(\phi)$ . Since we know that firms with higher productivity achieve higher profits from appendix A.2(e), we can define  $\phi_o^*$  as:

$$\Pi_{op}(\tilde{\phi}(\phi_o^*)) - f_o = \Pi(\phi_o^*) \quad (32)$$

(b) Show that increasing  $\hat{\beta}$  to 1 shifts the cutoff  $\phi_o^*$  down.

Above, we defined  $\tilde{\phi}(\phi_o^*)$  assuming that  $\beta = \hat{\beta} < \bar{\beta}$  in equation (29). However, if  $\hat{\beta}$  increased to 1 allowing  $\beta$  to increase to  $\bar{\beta}$ , then the inequalities in equations (30) and (31) would be even stronger. This means that offshoring now allows a firm to pretend to be even more productive than before - that is, for any given  $\phi$ ,  $\tilde{\phi}(\phi)$  is higher than before. Then, for the equality in equation (32) to hold,  $\phi_o^*$  must fall allowing for new entrants.

## Appendix A.4

First, looking at the FE condition, we easily derive both first and second derivatives of  $\bar{\pi}$  with respect to  $\phi^*$ :

$$\begin{aligned}\bar{\pi}(\phi^*) &= f_e(\phi^*)^k \\ \bar{\pi}'(\phi^*) &= k f_e(\phi^*)^{(k-1)} > 0 \\ \bar{\pi}''(\phi^*) &= (k-1) f_e(\phi^*)^{(k-2)} > 0\end{aligned}$$

Note that in deriving equation (16), we already had to place the stipulation that  $k > 1$  and clearly the last line holds under that condition. Thus, the FE condition is increasing and accelerating in the  $(\phi^*, \bar{\pi})$  space. Next, the ZCP condition from equation (17):

$$\bar{\pi}(\phi^*) = \frac{L}{\gamma} \underbrace{(p(\phi^*) - p(\bar{\phi}))}_{A} \underbrace{\frac{(\phi^* \frac{k}{k-1} p(\bar{\phi}) - w_x)}{\phi^* (\frac{k}{k-1}) (1 + \eta)}}_{B}$$

with the terms in the left and right braces being called A, and B, respectively. In order to draw the ZCP condition in the  $(\phi^*, \bar{\pi})$  space, I find  $\frac{dA}{d\phi^*}$  and  $\frac{dB}{d\phi^*}$ :

$$\frac{dA}{d\phi^*} = -\frac{w_x}{2k(\phi^*)^2}$$

$$\frac{dB}{d\phi^*} = \frac{w_x}{2(\frac{k}{k-1})(1 + \eta)(\phi^*)^2}$$

Now, taking the derivative of  $\bar{\pi}$  with respect to  $\phi^*$  and simplifying using the above gives:

$$\bar{\pi}'(\phi^*) = \frac{L}{\gamma} w_x B \left[ \frac{k-2}{2k(\phi^*)^2} \right]$$

This expression is negative when  $k < 2$ ; constant when  $k = 2$ ; and positive when  $k > 2$ . When  $k < 2$  or when  $k = 2$ , we have figures 1 and 2, and we can ensure a unique equilibrium where the ZCP and FE curves intersect. In the case where  $k > 2$  we take the

second derivative of the ZCP condition with respect to  $\phi^*$  and after simplifying, get:

$$\bar{\pi}''(\phi^*) = \frac{\frac{L}{\gamma} w_x}{2k(\phi^*)^3} \frac{[(1 + \eta)w_x(1 + 4(\frac{k}{k-1})(\phi^*)^2) - 4(\frac{k}{k-1})^2(\phi^*)^2 p(\bar{\phi})]}{2(\frac{k}{k-1})(1 + \eta)(\phi^*)^2} < 0$$

Upon closer inspection, the term inside the brackets is negative and hence the entire expression is negative. Summarizing, when  $k > 2$ , the ZCP condition is increasing but decelerating in the  $(\phi^*, \bar{\pi})$  space, while the FE condition is increasing and accelerating. However, to confirm the uniqueness and existence of an equilibrium, the FE condition at  $(\phi_{min} = 1)$  must be below the ZCP at  $(\phi_{min} = 1)$ , which can be satisfied if  $f_e, \gamma$  are small enough or  $L$  is large enough.

## Appendix A.5

Show that  $w'_x(\hat{\beta}) < 0$ , that is, the outside option of workers in sector  $Y$  must fall with offshoring.

Proof by contradiction: assume that  $w'_x(\hat{\beta}) > 0$  - the outside option rises with offshoring. Then, looking at equation (33) in appendix A.8, we would get that the ZCP curve shifts down with offshoring, meaning that average industry profits have fallen. Thus, in the new equilibrium, it must be that  $\phi^*$  falls. However, for the least productive firms, we have the following:

$$\frac{d\mu^D}{d\hat{\beta}} = -\frac{w'_x(\hat{\beta})}{2\phi(1 + \eta)} > 0$$

Hence, because the outside option of their workers has gone up, wage costs increase, and margins fall for purely domestic firms. Also,

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

Here, costs and prices will continue to fall for MNCs (otherwise, they would not offshore in equilibrium). However, costs and prices rise for purely domestic firms since their wage costs have increased and they have no benefit from offshoring. This corresponds to a loss

in quantity for purely domestic firms. Combined with the fall in margins, their profits unambiguously fall and they should be forced to exit. However, this is inconsistent with  $\phi^*$  falling in the new equilibrium and thus, we have a contradiction.

## Appendix A.6

Want to show that (a)  $\frac{dp^M}{d\hat{\beta}} > 0$ ; (b)  $\frac{dc^M}{d\hat{\beta}} > 0$ ; (c)  $\frac{d\mu^M}{d\hat{\beta}} < 0$ ; (d)  $\frac{d\pi_{op}^M}{d\hat{\beta}} < 0$ ; (e)  $\frac{dw^M}{d\hat{\beta}} < 0$ ; (f) ambiguously  $\frac{dq^M}{d\hat{\beta}} < 0$ ; (g) ambiguously  $\frac{d\Pi^M}{d\hat{\beta}} < 0$ . Before starting, I impose the necessary condition that  $w_f$  must be small enough to satisfy:  $w_x > w_f$ . Without this condition, offshoring is not cost effective for any firm and so no firm would choose to offshore.

(a) Show that  $\frac{dp^M}{d\hat{\beta}} > 0$ :

First, solve for the function  $D(p^M, \beta)$ , which implicitly solves the optimal price for the MNC firm:

$$D(p^M, \hat{\beta}) : -\frac{L}{\gamma}p^M + q - \frac{L}{\gamma} \left[ \frac{\eta\phi p^M + (1-\beta)w_x + \beta w_f}{\phi(1+\eta)} \right] - q \frac{\eta}{1+\eta} = 0$$

From the implicit function theorem, we know that  $\frac{dp^M}{d\hat{\beta}} = -\frac{\frac{\partial D(\cdot)}{\partial \hat{\beta}}}{\frac{\partial D(\cdot)}{\partial p^M}}$ :

$$\begin{aligned} \frac{\partial D(\cdot)}{\partial \hat{\beta}} &= \frac{L(1-\beta)w'_x - \beta'w_x + \beta'w_f}{\gamma\phi(1+\eta)} \\ \frac{\partial D(\cdot)}{\partial p^M} &= -\frac{L}{\gamma} \frac{2}{(1+\eta)} \\ \frac{dp^M}{d\hat{\beta}} &= \frac{(1-\beta)w'_x - \beta'[w_x - w_f]}{2\phi} < 0 \end{aligned}$$

(b)  $\frac{dc^M}{d\hat{\beta}} > 0$ ;

Remember that  $c = \frac{w^M}{\phi} = \frac{\eta\phi p^M + (1-\beta)w_x + \beta w_f}{\phi(1+\eta)}$ . Differentiating with respect to  $\hat{\beta}$ , plugging in for  $\frac{dp^M}{d\hat{\beta}}$  from (a) and simplifying gives:

$$\frac{dc^M}{d\hat{\beta}} = \frac{(2+\eta)[(1-\beta)w'_x - \beta'[w_x - w_f]]}{2\phi(1+\eta)} < 0$$

(c)  $\frac{d\mu^M}{d\hat{\beta}} < 0$ ;

Comparing (a) and (b), we see that:

$$\begin{aligned}\frac{dc^M}{d\hat{\beta}} &= \frac{dp^M}{d\hat{\beta}} \frac{(2 + \eta)}{(1 + \eta)} \\ \frac{dc^M}{d\hat{\beta}} &< \frac{dp^M}{d\hat{\beta}} \\ \frac{d\mu^M}{d\hat{\beta}} &> 0\end{aligned}$$

(d)  $\frac{d\pi_{op}^M}{d\hat{\beta}} < 0$ ;

Taking the derivative of equation (8) with respect to  $\hat{\beta}$  and plugging in for  $\frac{dp^M}{d\hat{\beta}}$ :

$$\frac{d\pi_{op}^M}{d\hat{\beta}} = \frac{(1 - \beta)[\beta'(w_x - w_f) - (1 - \beta)w'_x] + 2\pi_{op}^M}{2(1 - \beta)^2(1 + \eta)^2} > 0$$

Moreover, I find:

$$\frac{\partial\left(\frac{\partial\pi_{op}^M}{\partial\hat{\beta}}\right)}{\partial\phi} = \frac{\partial\pi_{op}^M}{\partial\phi} > 0$$

where the inequality holds because we know that  $\frac{d\pi_{op}^M}{d\hat{\beta}} > 0$  from appendix A.2(g). The above implies that operating profits-per-worker increase for MNCs post-offshoring and further they increase more for more productive firms.

(e)  $\frac{dw^M}{d\hat{\beta}} < 0$ ; Taking the derivative of equation (??) with respect to  $\hat{\beta}$  and plugging in from part (f) gives:

$$\begin{aligned}\frac{dw^M}{d\hat{\beta}} &= \eta \frac{\partial\pi_{op}^M}{\partial\hat{\beta}} + w'_x \\ \frac{dw^M}{d\hat{\beta}} &= \frac{\eta(1 - \beta)[\beta'(w_x - w_f)] + (2 + \eta)(1 - \beta)^2 w'_x + 2\pi_{op}^M \eta}{2(1 - \beta)^2(1 + \eta)}\end{aligned}$$

Define an  $\hat{\phi}$  such that the above equals zero:

$$\pi_{op}^M(\hat{\phi}) = \frac{-\eta(1 - \beta)\beta'[w_x - w_f] - (2 + \eta)(1 - \beta)^2 w'_x}{2\eta}$$

Since the right-hand side is independent of  $\phi$ , and we know that  $\frac{d\pi_{op}^M}{d\hat{\beta}} > 0$  from A.2 (f), then clearly for  $\phi > \hat{\phi}$ , wages increase and for  $\phi < \hat{\phi}$ , wages decrease.

$$(f) \frac{dq^M}{d\hat{\beta}} < 0;$$

Taking the derivative of equation (5) with respect to  $\beta$ :

$$\frac{dq^M}{d\hat{\beta}} = \frac{L}{\gamma} \left[ \frac{\lambda M}{\lambda M + \gamma} \frac{d\bar{P}_y}{d\hat{\beta}} \right] - \frac{dp^M}{d\hat{\beta}}$$

For MNCs, prices fall more than for purely domestic firms: compare appendix A.6(a) with A.7(a). Hence,  $\frac{dp^M}{d\hat{\beta}} > \frac{d\bar{P}_y}{d\hat{\beta}}$  implying that  $\frac{dq^M}{d\hat{\beta}} < 0$  and quantity increases with offshoring (positive "business-stealing effect" for MNCs).

$$(g) \frac{d\Pi^M}{d\hat{\beta}} < 0;$$

From part (c), we know that margins are increasing with offshoring and from part (d) we know that quantity is increasing with offshoring. Hence, operating profits for MNCs would be clearly increasing with offshoring.

## Appendix A.7

Want to show that (a)  $\frac{dp^D}{d\hat{\beta}} > 0$ ; (b)  $\frac{dc^D}{d\hat{\beta}} > 0$ ; (c)  $\frac{d\mu^D}{d\hat{\beta}} < 0$ ; (d)  $\frac{d\pi_{op}^D}{d\hat{\beta}} < 0$ ; (e)  $\frac{dw^D}{d\hat{\beta}} > 0$ ; (f) ambiguously  $\frac{dq^D}{d\hat{\beta}} > 0$ ; (g) ambiguously  $\frac{d\Pi^D}{d\hat{\beta}} < 0$ .

$$(a) \text{ Show } \frac{dp^D}{d\hat{\beta}} > 0:$$

To solve for  $\frac{dp^D}{d\hat{\beta}}$ , remember the function  $D(p^D, \hat{\beta})$  - equation (14) - which implicitly solves the optimal price for the purely domestic firm:

$$D(p, \beta) : -\frac{L}{\gamma}p + q - \frac{L}{\gamma} \frac{\eta \phi p^D + w_x}{\phi(1 + \eta)} - q \frac{\eta}{1 + \eta} = 0$$

From the implicit function theorem, we know that  $\frac{dp^D}{d\hat{\beta}} = -\frac{\frac{\partial D(\cdot)}{\partial \hat{\beta}}}{\frac{\partial D(\cdot)}{\partial p^D}}$ :

$$\begin{aligned} \frac{\partial D(\cdot)}{\partial \hat{\beta}} &= -\frac{L}{\gamma} \frac{w'_x(\hat{\beta})}{\phi(1 + \eta)} \\ \frac{\partial D(\cdot)}{\partial p^D} &= -\frac{L}{\gamma} \frac{2}{(1 + \eta)} \\ \frac{dp^D}{d\hat{\beta}} &= \frac{w'_x(\hat{\beta})}{2\phi} > 0 \end{aligned}$$

(b) Show  $\frac{dc^D}{d\hat{\beta}} > 0$ ;

Remember that marginal costs =  $\frac{w^D}{\phi} = \frac{\eta\phi p + w_x(\hat{\beta})}{\phi(1+\eta)}$ . Differentiating with respect to  $\hat{\beta}$ , plugging in for  $\frac{dp^D}{d\hat{\beta}}$  from (a) and simplifying gives:

$$\frac{dc^D}{d\hat{\beta}} = \frac{(2 + \eta)w'_x(\hat{\beta})}{2\phi(1 + \eta)} > 0$$

(c) Show  $\frac{d\mu^D}{d\hat{\beta}} < 0$ ;

Comparing (a) and (b), we see that:

$$\begin{aligned} \frac{d\mu^D}{d\hat{\beta}} &= \frac{dp^D}{d\hat{\beta}} - \frac{dc^D}{d\hat{\beta}} \\ \frac{d\mu^D}{d\hat{\beta}} &= -\frac{w'_x(\hat{\beta})}{2\phi(1 + \eta)} < 0 \end{aligned}$$

(d) Show  $\frac{d\pi_{op}^D}{d\hat{\beta}} < 0$ ;

Taking the derivative of equation (11) with respect to  $\hat{\beta}$  and plugging in for  $\frac{dp^D}{d\hat{\beta}}$ :

$$\frac{d\pi_{op}^D}{d\hat{\beta}} = -\frac{w'_x(\hat{\beta})}{2(1 + \eta)} < 0$$

(e) Show  $\frac{dw^D}{d\hat{\beta}} > 0$ ;

Taking the derivative of equation (??) with respect to  $\hat{\beta}$  and plugging in for  $\frac{dp^D}{d\hat{\beta}}$ :

$$\frac{dw^D}{d\hat{\beta}} = \frac{(2 + \eta)w'_x(\hat{\beta})}{2(1 + \eta)} > 0$$

(f) Show  $\frac{dq^D}{d\hat{\beta}} > 0$ ;

Taking the derivative of equation (5) with respect to  $\hat{\beta}$ :

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

For purely domestic firms, prices fall less than for MNC firms: compare appendix A.6(a) with A.7(a). Hence,  $\frac{dp^D}{d\hat{\beta}} < \frac{d\bar{P}_y}{d\hat{\beta}}$  implying that for sufficiently small  $\gamma$ ,  $\frac{dq^D}{d\hat{\beta}} < 0$  and quantity decreases for purely domestic firms ("business-stealing effect").

(g) Show  $\frac{d\Pi^D}{d\hat{\beta}} < 0$ ;

## Appendix A.8

I want to show that the ZCP condition shifts up with offshoring when  $\bar{\phi}$  represents a purely domestic firm.

From equation (17), the ZCP condition:

$$\bar{\pi}(\phi^*) = \frac{\frac{L}{\gamma}(p(\phi^*) - p(\bar{\phi}))(\phi^* \frac{k}{k-1} p(\bar{\phi}) - w_x)}{\phi^* (\frac{k}{k-1})(1 + \eta)}$$

Taking the derivative with respect to  $\hat{\beta}$  and plugging in for  $\frac{\partial p}{\partial \hat{\beta}}$  appropriately:

$$\frac{d\bar{\pi}}{d\hat{\beta}} = \frac{L}{\gamma} \left[ \left( \frac{\partial p_{max}}{\partial \hat{\beta}} - \frac{dp(\bar{\phi})}{d\hat{\beta}} \right) (\mu(\bar{\phi})) + (p_{max} - p(\bar{\phi})) \left( -\frac{w'_x}{2\bar{\phi}(1 + \eta)} \right) \right] \quad (33)$$

Notice that the second term within the brackets is negative and represents the positive productivity effect from offshoring. The first term should be positive for purely domestic firms and represents the negative business-stealing effect.

Now, I employ a proof by contradiction technique. Assume that the ZCP condition shifts down with offshoring, meaning that  $\phi^*$  would fall in the new equilibrium and hence  $p_{max}$  (remember  $p_{max} = p(\phi^*)$ ) would rise. However, then we get that the first term in equation (33) above would be negative and the whole expression would be negative indicating that the ZCP curve shifts up. Hence, we have a contradiction.

## Appendix A.9

Technically, offshoring should also affect firm-level variables through changes in  $\phi^*$ ,  $M$ , which affect product market competition. An increase in  $\phi^*$  would shift the  $\Pi$  curve out in figure 8, as the profits of all firms would increase. If profits increase, firms with productivity  $\phi$  slightly less than  $\phi^*$  would be able to enter and  $\phi^*$  would fall and in turn this entry would drive profits down. This would continue until an equilibrium was reached. However, in my proofs in appendix A.6, A.7, I assume this effect does not exist. While

this assumption is made for mathematical expediency, it should cause no worries as it has no material ramifications on any results. Rather, if I took into account the product market competition,  $\phi^*$  and  $\phi_x^*$  would be slightly to the left of where they are now in figure 8. However, propositions 1-5 would not change. I do allow changes in  $\phi^*$ ,  $M$  to affect aggregate variables such as  $\bar{P}_y$ ,  $\bar{\Pi}$ ,  $\bar{\phi}$ , and  $L_y$ , as detailed in the body of the paper.

## Appendix A.10

### Variable definitions - BEA data, all values reported in dollars.

Vertical FDI	(Sales by affiliate to US parent + sales by affiliate to other local affiliates in the foreign country + sales by affiliate to other foreign affiliates) aggregated over all of the affiliates of a US parent. This value is deflated by the producer price index.
Sales	Total sales as reported for the US parent, deflated by the producer price index.
Vertical FDI share of sales	Vertical FDI/Sales.
R&D	R&D expenditures as reported for the US parent, deflated by the producer price index.
Domestic Employees	Total number of employees at the US parent.
Operating Profits	Sales - COGS - SG&A, where COGS and SG&A are reported for the US parent. This value is then deflated using the producer price index.
Operating Profits-per-US worker	Operating Profits/Domestic Employees.
Employee Compensation	Total wages and benefits paid for domestic employees as reported for the US parent, deflated by the consumer price index.
Average Wage	Employee Compensation/Domestic Employees.
Skilled Labor (industry-level)	Number of employees, for a given SIC code, with at least one year of education beyond high school as reported in the March CPS data.
Unskilled Labor (industry-level)	Number of employees, for a given SIC code, with high school education or less as reported in the March CPS data.
Labor Skill Ratio (industry-level)	Skilled Labor/Unskilled Labor, for a given SIC code.
Sales <sub>1</sub> - Sales <sub>8</sub>	Total sales for the top 8 business lines as reported for the US parent, by SIC codes, deflated by the producer price index.
Labor Skill Ratio (firm-level)	Labor Skill Ratio (industry-level) weighted by share of sales for each of the top 8 business lines for the US parent.

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## Tables

**Table 1 - Summary Statistics for Treatment versus Control - 1993**

	Treatment	Control	Difference
Log (global sales)	14.37 (0.13)	13.74 (0.10)	0.63*** (0.16)
Log (US employees)	9.09 (0.11)	8.44 (0.09)	0.65*** (0.14)
Log (R&D)	10.68 (0.17)	9.74 (0.12)	0.94*** (0.20)
Log (op. profits-per-US emp)	4.94 (0.04)	4.96 (0.05)	-0.02 (0.07)
Labor skill ratio	2.01 (0.10)	1.61 (0.07)	0.40*** (0.12)
Vertical FDI (to Mexico) share of sales		0.01 (0.00)	
Log (average wage)	3.95 (0.03)	3.91 (0.02)	0.03 (0.03)
# Observations	242	166	

\*\* statistically significant at 5% level

\*\*\* statistically significant at 1% level

Note: Treatment refers to firms who offshored to Mexico in 1993 and control refers to firms who offshored to other Latin American countries but not Mexico in 1993.

**Table 2 - Dependent variable is differenced over the 1993 - 1997 period**

	$\Delta$ VFDI/Sales	$\Delta$ Log(Op Profits/US Employee)	$\Delta$ Log(Avg Wages)	$\Delta$ Log(Employment)	$\Delta$ Skill Ratio
Treatment (1)	0.0081*** (0.0031)	0.0783* (0.0474)	0.0741* (0.0418)	-0.0601 (.0581)	0.1608** (0.0832)
# Observations	335	332	332	335	334
Treatment (2)	0.0089*** (0.0032)	0.0718* (0.0459)	0.0658* (0.0401)	-0.0573 (0.0555)	0.1692** (.0808)
# Observations	356	353	353	356	355

(1) Comparison group is MNCs who offshore to Latin America but not Mexico, in 1993

(2) Comparison group is MNCs who offshore to other upper middle income countries but not Mexico, in 1993

\* statistically significant at 10% level

\*\* statistically significant at 5% level

\*\*\* statistically significant at 1% level

*Robust standard errors in parentheses*

*Industry fixed effects are included in the regression but not shown here*

**Table 3 - Dependent variable is differenced over the 1993 - 1997 and 1997 - 2001 periods**

	$\Delta$ VFDI/Sales	$\Delta$ Log(Op Profits/US Employee)	$\Delta$ Log(Avg Wages)
Interact (1)	-0.0061** (0.0028)	-0.1148* (0.0727)	-0.1453** (0.0679)
Treatment	0.0051*** (0.0019)	0.0448 (0.0524)	0.0906* (0.0514)
Period	-0.0006 (0.0014)	-0.0860* (0.0557)	0.1805*** (0.0528)
# Observations	474	465	476
Interact (2)	-0.0065** (0.0028)	-0.0974 (0.0700)	-0.1448** (0.0639)
Treatment	0.0055*** (0.0019)	0.0406 (0.0513)	0.0760* (0.0481)
Period	0.0002 (0.0013)	-0.1054** (0.0517)	0.1832*** (0.0479)
# Observations	510	499	512

(1) Comparison group is MNCs who offshore to Latin America but not Mexico, in 1993/97

(2) Comparison group is MNCs who offshore to other upper middle income countries but not Mexico, in 1993/97

\* statistically significant at 10% level

\*\* statistically significant at 5% level

\*\*\* statistically significant at 1% level

*Robust standard errors in parentheses*

*Industry fixed effects are included in the regression but not shown here*

**Table 4 - Dependent variable is differenced over the 1993 - 1997 period**

---

	$\Delta \text{Log}(\text{Avg Wages})$
Treatment (1)	0.0014 (0.0369)
Treatment*Rent-Sharing	0.5408* (0.2923)
# Observations	327

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Treatment (2)	-0.0063 (0.0360)
Treatment*Rent-Sharing	0.5304* (0.2814)
# Observations	348

---

(1) Comparison group is MNCs who offshore to Latin America but not Mexico, in 1997

(2) Comparison group is MNCs who offshore to other upper middle income countries but not Mexico, in 1997

\* statistically significant at 10% level

\*\* statistically significant at 5% level

\*\*\* statistically significant at 1% level

*Robust standard errors in parentheses*

*Industry fixed effects are included in the regression but not shown here*

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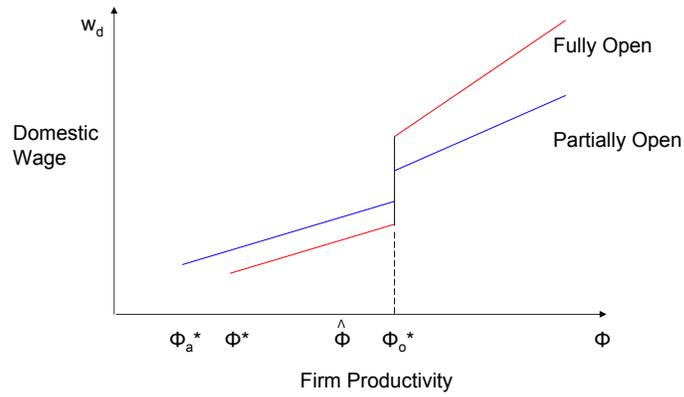


Figure 1: Wage changes under offshoring with  $\hat{\phi} < \phi_o^*$

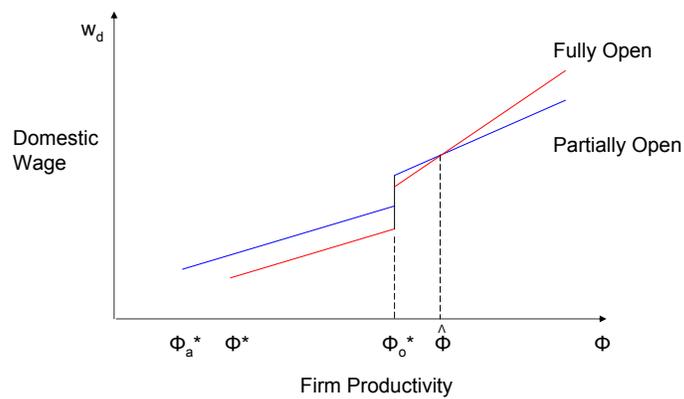


Figure 2: Wage changes under offshoring with  $\hat{\phi} > \phi_o^*$

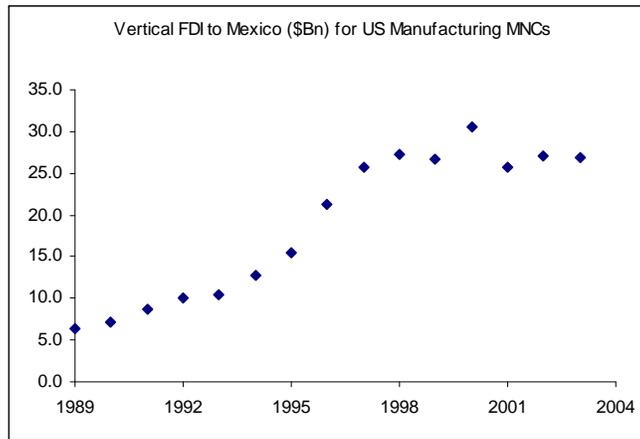


Figure 3: Vertical FDI from US Manufacturing to Mexico over Time

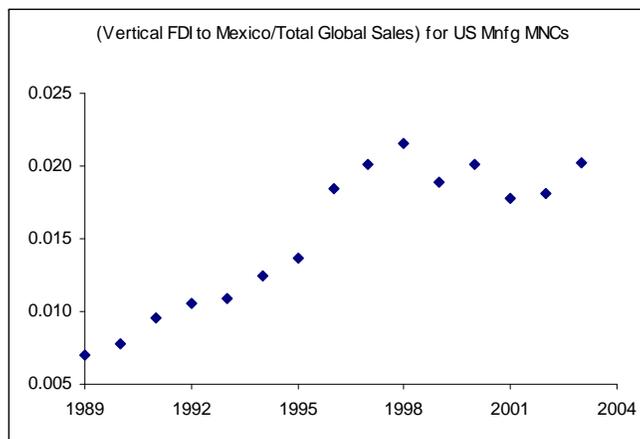


Figure 4: Vertical FDI Share from US Manufacturing to Mexico over Time