Offshoring, Wages, and Employment: Theory and Evidence*

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Abstract

This paper investigates the wage and employment effects of offshoring. I use firm-level data and two events in Mexico as a natural experiment to identify the effects of a fall in the marginal cost of offshoring to Mexico. I find that domestic wages actually rise at US firms that take advantage of this new offshoring opportunity. At the same time, domestic wages fall at US firms that do not take advantage. Furthermore, I find no evidence of greater job loss at offshoring firms relative to non-offshoring firms. These findings are consistent with productivity effects from offshoring. To explain the mechanism, I develop a theoretical framework that combines heterogeneous firms with imperfect labor markets and rent-sharing. Offshoring allows those firms to increase their productivity and profitability at the expense of non-offshoring firms. Through rent-sharing, this channel leads to higher domestic wages at offshoring firms and lower domestic wages at non-offshoring firms. Further, the predicted effect on domestic employment is ambiguous at the former but negative at the latter, consistent with the empirical findings.

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1 Introduction and Motivation

Offshoring[1] has been a source of controversy under the charge that it hurts the American worker. This view contends that firms that offshore reduce wages and shed jobs. However, economists have long challenged these notions. One instance that received a lot of attention occurred when 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."[2] But as we also know, trade can lead to welfare gains in the aggregate, yet produce "winners" and "losers". If offshoring is the latest manifestation of gains from trade, then who are the winners and losers?

To investigate this question, I focus on the implications of the productivity effects related to offshoring. To that end, I extend certain aspects of the Grossman and Rossi-Hansberg (2008) model to derive and test firm-level predictions on the productivity effects from offshoring. To summarize the findings, I find that profitability and average domestic wages actually rise at offshoring firms who take advantage of a new offshoring opportunity. Rather, profitability and average domestic wages fall at non-offshoring firms. Second, while there may be employment losses at offshoring firms, it is no greater than employment losses at non-offshoring firms. This results are consistent with evidence of productivity effects from offshoring. While this productivity channel is detailed carefully in the theoretical section, let me provide a simple preview of the channel now.

Imagine the existence of a technology that firms can acquire by paying some up-front costs. Amongst heterogeneous firms, some would be able to afford this technology while others would not. Once it is acquired, this technology would replace some workers at the acquiring firm, but would make the firm more productive/efficient as a whole by lowering its marginal costs of production. This efficiency gain would enable these firms to gain a competitive edge vis-a-vis the firms that were unable to acquire this technology leading to a business-stealing effect and a reallocation of production and profits towards the more highly productive firms. This efficiency gain at offshoring firms partly offsets the direct loss of jobs and can explain the finding of muted employment losses at these firms. Further, jobs at non-offshoring firms are vulnerable due to the loss of competitiveness at these firms. Finally, if wages are tied to the profitability of the firm, average worker wages would rise at the more productive firm and fall at the disadvantaged firms. I label the above channel as the productivity plus rent-sharing ("PRS") channel. One can immediately imagine many technologies that drive this channel, but in this paper, offshoring is that technology.

In this paper, I think of the productivity effect/efficiency gain from offshoring simply as lowering the marginal costs of production for the offshoring firm. However, it is possible to think of additional, potentially more powerful, productivity benefits. For example, if a firm is able to offshore its non-core tasks and focus on its core tasks, there could be productivity gains from

[1]Following Grossman and Helpman (2002), Trefler (2005), I define offshoring to include the movement of production processes abroad but kept within the firm (vertical FDI) as well as arms-length transactions (offshore outsourcing). While the model can incorporate both modes, the data does not include information on arms-length transactions. Therefore, in the empirical analysis, I restrict offshoring to vertical FDI, which is measured as intrafirm affiliate sales.

[2]See Mankiw and Swagel (2006).

specialization. Also, the firm could re-invest the cost savings from offshoring in research and innovation providing long-term productivity boosts. Examining these other productivity channels are interesting avenues for future research.

While the idea of productivity effects from offshoring has been around in the literature, I extend previous work[3] to develop firm-level predictions that can be carefully tested empirically. The model developed here combines existing frameworks to generate new firm-level predictions on the effects of offshoring on wages, employment, and wage inequality. The main prediction being that offshoring, through a productivity effect, increases domestic wages at offshoring firms while lowering domestic wages at non-offshoring firms and increasing withing-group inequality. Placing the productivity effect from offshoring in the context of heterogeneous firms (rather than at the industry or country-level) has an additional benefit: it allows me to take advantage of firm-level data and better identify the causal link between offshoring and wages. Merely demonstrating that offshoring firms pay higher wages is not sufficient as offshoring and wages are endogenous. High wages may cause a firm to offshore, or a third factor such as productivity could cause a firm to pay high wages and offshore. Therefore, employing firm-level data and an exogenous experiment as an identification strategy, I can provide causal evidence that increased offshoring led to higher firm-level wages.

In particular, for the identification strategy, I taking advantage of two episodes in Mexico as a shock to the marginal cost of offshoring to Mexico for US firms.[4] First, the FDI law of 1993 relaxed restrictions and reduced both pecuniary and non-pecuniary costs of foreign ownership of Mexican firms.[5] 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. Next, firms are separated into treatment and control groups where the treatment group includes US firms with an offshoring presence in Mexico as of 1993. These firms, having already paid the fixed costs of entry, would be positioned to take advantage of a fall in the marginal cost of offshoring. The control firms include US firms that offshore to other Latin American countries excepting Mexico as of 1993.[6] These firms would be less likely to respond to a fall in the marginal cost of offshoring since they would have to still pay the fixed entry cost. Comparing, I find that offshoring, operating profits per domestic worker, and average domestic wages increased more for treatment than control 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 operating profits per domestic worker, increases within-group (where group is the sector) wage dispersion. Additionally, this

[3]Grossman and Rossi-Hansberg (2008) offer a nice general equilibrium model for thinking about the effects of offshoring at the sector-level.

[4]There are fixed and marginal costs associated with offshoring. The theory and empirics focus on a shock to the marginal cost of offshoring.

[5]The new law streamlined and expedited the administrative procedures, reduced to a minimum the exercise of discretionary powers by Mexican authorities and increased foreign ownership limits from 49% to 100% in all manufacturing and some service industries.

[6]For robustness, I consider additional comparison groups, which are discussed in section 8.

empirical analysis finds that there is no evidence of greater job loss at treatment firms relative to control firms.

One potential issue is that a labor composition effect - similar to Feenstra and Hanson (1996) - could also be consistent with the aforementioned findings. If MNC firms offshore the lowest-paying jobs, then average domestic wages would increase mechanically with offshoring. To address this issue, I perform several robustness checks, including showing that average domestic wages likely increased more for treatment firms in industries with higher rent-sharing, which supports the mechanism discussed in this paper.

Section 2 delves further into related literature. Sections 3 and 4 develop the theoretical framework and section 5 examines the comparative statics given an exogenous fall in the marginal cost of offshoring. Section 6 describes the data and presents some descriptive statistics. Section 7 provides background on the episodes in Mexico, describes the empirical methodology and presents the main results. Section 8 addresses alternative hypotheses. Finally, Section 9 concludes.

2 Related Literature

Dramatic improvements in transportation and communication technology are changing the rules on what can be produced domestically versus abroad. Increasingly, firms can separate the production process globally to take advantage of factor cost differences without sacrificing gains from specialization. Numerous papers provide empirical evidence demonstrating the strength in this trend of vertical fragmentation.[7] Further, Blinder (2006) argues that with continued technological advances, the scope for services offshoring is significant and when combined with manufacturing offshoring up to 20-25% of American jobs could be vulnerable.

The concern 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 inward and lower wages. Additionally, 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. However, these arguments constitute only part of the story as offshoring also reduces costs and improves the productivity of a firm. In a recent paper, Grossman and Rossi-Hansberg (2008) demonstrate that this productivity effect can actually lead to higher wages for domestic workers whose tasks are easier to offshore.

Several recent theoretical papers have looked at the labor market impacts of offshoring. Mitra and Ranjan (2007) also use search frictions in a model with heterogeneous firms under offshoring. However, their focus is on the effects of offshoring on employment; since wages do not vary across

[7] Yeats (2001) finds that trade in intermediate goods has been growing at a much faster rate than trade in final goods and accounts for 30% of world trade in manufacturing. Hummels, Ishii and Yi (2001) and Borga and Zeile (2004) similarly demonstrate that the share of intermediate goods trade in total world trade has increased significantly in recent decades.

firms in their model, they do not offer firm-level impacts of offshoring on wages.[8] Davidson, Matusz, and Shevchenko (2008) examine matching between heterogeneous firms and workers where high-tech job are offshorable. They predict that both high-skilled and low-skilled domestic workers lose in the short-run; high-skilled workers because they must accept low-skilled jobs and low-skilled workers because they are now competing with domestic high-skilled workers for these jobs. Multiple equilibria are possible in the long run depending on workers' expectations. Their model does not deal directly with the productivity effects of offshoring, which is the main focus of my paper. In Antras, Garicano, and Rossi-Hansberg (2006), offshoring results in better matching between heterogeneous managers and workers, leading to distributional predictions at the team/firm-level. In addition to focusing on a different mechanism, this paper models the effect of a marginal liberalization in offshoring rather than a move from complete autarky to complete offshoring. No model that moves from autarky to fully open offshoring is truly testable; hence, modeling marginal liberalization allows for a better connection between theory and data.

Meanwhile, wage inequality within the US 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 major role, evidence exists that within-group wage inequality also appears to contribute to overall wage inequality. Autor, Katz, and Kearney (2008) find that both overall inequality and residual inequality - wage dispersion within demographic and skill groups - has increased at the upper tail (90-50 percentile) of the distribution but has stagnated at the lower tail (50-10 percentile). Several papers have combined heterogeneous firms with imperfect labor markets in a trade context to derive implications on wages and wage inequality.[9] This paper differentiates itself from this literature in two ways. First, these trade models generally assume movement of final goods but not intermediate goods, which as mentioned previously, is a significant and increasing share of total trade. This distinction matters further because the mechanisms are slightly different between trade in final goods and offshoring. In these papers, under final goods trade, distributional consequences on wages channel primarily through variations in market share. However, in addition to production reallocation, the channel proposed here also operates through variations in the productivity effect from offshoring. Furthermore, a crucial contribution of this paper is that I am able to bridge the gap between theory and evidence by bringing theoretical predictions to the data.

In the empirical literature, numerous papers have tried to estimate the effects of globalization on wage volatility and employment. Slaughter et al. (2001, 2004, 2007) offer evidence that globalization has increased the elasticity of labor demand, therefore increasing the wage volatility of workers.[10] There is also a fairly extensive literature investigating the impacts of foreign employ-

[8] They do offer firm-level impacts of offshoring on employment, which are similar to the business-stealing effects in this paper.

[9] Egger and Kreickemeier (2007); Davidson, Matusz, and Shevchenko (2008); Felbermayr, Pratt, and Schmerer (2008); Helpman, Itskhoki, and Redding (2008); Amiti and Davis (2008).

[10] Karabay and McLaren (2006) propose a different mechanism where offshoring leads to increased volatility of wages in the offshoring country. Risk-averse workers accept a wage from risk-neutral firms below the spot rate in return for wage smoothing. However, new outsourcing opportunities make it more attractive for firms to deviate from the

ment on domestic employment, though the findings in this literature are quite mixed.[11]

Head and Ries (2002) use firm-level Japanese manufacturing data to find evidence in support of the Feenstra and Hanson composition effect, which proposes that offshoring changes average domestic wages at the firm-level through changes in the average skill composition of the firm's domestic work force. Liu and Trefler (2008) consider both services outsourcing plus insourcing to India and China and find very small positive effects on American wages at the industry- and occupation-level. Egger and Egger (2003) use the fall of the Iron Curtain as an exogenous shock and find that increased outsourcing to Eastern Europe and the former Soviet Union increased the relative demand of skilled workers in Austria. Their analysis is also performed at the industry-level. While I also find evidence of a composition effect, the focus of this paper is to provide evidence of a different channel: the productivity plus rent-sharing mechanism that is detailed in the theoretical section. Closer to this paper, Harrison and McMillan (2008) find that foreign employment complements domestic employment at vertically integrated firms, which is consistent with a productivity effect from offshoring.

In particular, the empirical analysis here contributes to the existing literature by being the first to combine the following three elements: (1) firm-level analysis; (2) a natural experiment that acts as an exogenous shock to the marginal cost of offshoring to better identify the causal link; (3) more nuanced data that allows for a better measurement of offshoring activity.

Why are these three features important? First, by analyzing the effects of offshoring at the firm-level, I offer and test new predictions on the relative firm-level winners and losers from offshoring. Second, a firm-level analysis allows me to take advantage of episodes from Mexico as an exogenous shock to the marginal cost of offshoring for US firms to Mexico. This methodology establishes a more convincing causal link from offshoring to outcome variables of interest. Finally, existing empirical papers on offshoring and labor-market outcomes have not always made a clear distinction between the different motives for engaging in foreign direct investment (FDI): the motive to jump trade barriers and sell in the foreign market (horizontal FDI), and the motive to take advantage of lower production costs in the foreign market (vertical FDI).[12] However, for the purposes of understanding the effects of offshoring, it is critical to separate between the two types of FDI expansion. A key advantage of the BEA data is that they allow one to observe the share of foreign affiliates sales that are to the U.S. headquarters or other affiliates of the same MNC, as opposed to arms-length sales to non-affiliated companies. Using this to proxy for the extent of

wage smoothing contract leading to increased wage volatility. Krebs, Krishna, and Maloney (2005) find that trade policy changes lead to increased income risk and welfare costs, especially in the short-run. See also Munch (2005), Egger, Pfaffermayr, and Weber (2007), and Geishecker (2008) who find that offshoring increases the probability of job dislocation.

[11]See Blomstrom, Fors, and Lipsey (1997), Brainard and Riker (2001); Hanson, Mataloni, and Slaughter (2003); Desai, Foley, and Hines (2005) for the US. See also Braconier and Ekholm (2000), Navaretti and Castellani (2004), Becker, Ekholm, Jackle, and Muendler (2005), and Konings and Murphy (2006) for employment effects in Sweden, Germany, the EU, and Italy.

[12]Some papers tackle this issue by assuming that activity in less-developed countries can proxy for vertical FDI and activity in developed countries can proxy for horizontal FDI. However, this is unsatisfactory as the BEA data reveals that significant amounts of vertical and horizontal activities occur in both low-income countries and high-income countries.

offshoring motivated by vertical considerations, this paper offers a critical improvement in the measurement of offshoring.

3 Model Preliminaries

There are two stages in the model. In the first stage, workers and firms first engage in the labor market interaction and set wages. In the second stage, firms compete with each other under monopolistic competition with offshoring opportunities.

3.1 Production and Offshoring Technology

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 is the numeraire and production in sector X employs a simple constant returns to scale technology.[13] 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. Production requires only one factor, labor. Firms pay a fixed entry cost (f_e) to learn their productivity parameter from distribution $G(\phi)$. Then, once they realize their productivity, firms act in two stages. First, in the labor market interaction, they search, match, interview, and bargain over wages with workers. Second, they maximize profits under monopolistic competition in the product market. Production involves a fixed cost of f_d. Firms that expect to make negative profits exit immediately and the rest remain active in the sector.

The production of a unit of a differentiated good in sector Y requires a continuum of tasks, indexed by $z \in [0, 1]$. Following the terminology of Leamer and Storper (2001), low z tasks can be thought of as codifiable whereas high z tasks require "tacit information", which is best communicated through face-to-face relationships. Similarly, Autor, Levy, and Murnane (2003) distinguish between routine (low z) and non-routine (high z) tasks, where the former are easier to offshore because they can be described by a simple algorithm. Here, the continuum for z is not related to skill, since all workers are homogeneous. Rather, within skill-type, some tasks are easier to codify than others.[14]

Next, the production function is linear, $q = \phi N(\phi)$, where $N(\phi)$ is the employment level at a firm with productivity ϕ. Without loss of generality, I assume that each task requires an equal share s of $N(\phi)$ and this is the same across all firms in sector Y. So, at any firm, $sN(\phi)$ workers are

[13] It is straightforward to endogenize the wage in sector X by allowing for decreasing returns to labor there. Then, as labor flows into sector X, the outside option for workers in sector Y falls, tending to reinforce the effect found here.

[14] Blinder (2006) argues that traditional notions of skill do not necessarily correlate with vulnerability of a job to offshoring. Rather the new divide could be along the codifiable/routine versus tacit/non-routine distinction, not necessarily by skill.

performing any task z. Note that assuming a constant s for each task means that z also captures the share of a firm's workforce employed in tasks $[0..z]$.[15] The direct foreign cost of performing any task z is $sN(\phi)w_f$,[16] where w_f is assumed to be the exogenous wage of a foreign worker.

Now, a brief explanation on the assumption of an exogenous foreign wage that is common to all firms. While there is evidence that MNCs pay higher wages than local firms in the foreign country for the same type of worker (see Aitken, Harrison, and Lipsey (1996)), there is no evidence that MNCs pay different wages amongst each other for the same type of foreign worker. Hence, I assume that all MNCs face a common w_f in the foreign country. For completeness, appendix 1 discusses in detail the implications of relaxing this assumption.[17]

In addition, offshoring is associated with two other costs. First, borrowing from Grossman and Rossi-Hansberg (2008), $t(z)$ captures the monitoring/technological costs of offshoring task z, with $t'(z) > 0$. That is, as tasks become more non-routine, they become increasingly difficult/costly to monitor from a distance. I assume that $\lim_{z \to 1} t(z) \to \infty$, reflecting that the most non-routine tasks are impossible to offshore.[18] Second, there is a policy-related cost, $\beta > 1$, which is the same for all firms and captures the idea that government regulations impose additional costs to offshoring.[19] Hence, the marginal cost of offshoring task z becomes $\beta t(z) s N w_f$.[20] Finally, for simplification, firms in sector Y can import intermediate goods (trade in tasks) but not trade in final goods.

3.2 Labor Market

Labor is perfectly competitive in sector X and is paid its marginal product of labor, w_x. 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, the labor market clearing condition is: $L = L_x + L_y$.

Unlike the labor market in sector X, the labor market in sector Y is not perfectly competitive and functions in the following three steps. First, 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. Simultaneously, a firm with productivity ϕ pays search costs $b(\phi)$ to post a vacancy and randomly match with a worker. In particular, I assume convex hiring costs, such that $b'(\phi) > 0$.[21] Then,

[15] The assumption of a constant s is not required but serves to simplify the mathematical exposition.

[16] $sN(\phi)w_f$ is the foreign cost of performing a task and is invariant to whether that task is performed abroad within the firm or is outsourced through an arms-length transaction.

[17] Summarizing the discussion in appendix 1, if foreign wages were endogenous but still were the same for all MNCs, nothing would change. If foreign wages were endogenized such that different MNCs faced different foreign wages, the main predictions of the model would still hold. However, it would have implications on the domestic wage profile at the top end of the distribution. In particular, it could be that the wage profile at the top end of the wage distribution converges. See figure 1.

[18] This assumption ensures that in equilibrium no firm will choose to offshore all tasks.

[19] For example, in the empirical exercise, the Mexican FDI law of 1993 streamlined and expedited the administrative procedures, reduced the ad-hoc, discretionary powers of Mexican authorities and increased foreign ownership limits from 49% to 100% in all manufacturing and some service industries.

[20] The marginal cost of offshoring described here is similar to offshoring costs in Grossman and Rossi-Hansberg (2008). β here, which captures foreign policy regulation of incoming FDI can be thought of as a specific version of their more general shift parameter.

[21] While the assumption of $b'(\phi) > 0$ is somewhat ad-hoc, it is a reduced form assumption that is consistent with empirical evidence. Cosar, Guner, and Tybout (2010) estimate and find evidence in Columbia of convexities in a firm's

in the second step, workers and vacancies at firms are randomly matched. Workers who do not match in this step move to sector X and earn w_x.

Finally, in the third step, a hired worker and the firm bargain over the surplus created from their union where the joint surplus is allocated by Nash bargaining. The surplus that accrues to a workers is the difference between the wage earned at that firm and the worker's outside option, which is to move to sector X and earn w_x. The surplus for the firm is the marginal profitability from that domestic worker. The firm is assumed to bargain simultaneously with all N_d domestic workers. Therefore, each worker is treated as the N_d^{th} worker, where the other $N_d - 1$ workers have already agreed on a wage.[22] The Nash bargaining game between a domestic worker and a firm is as follows:

$$\max_{w_d} \theta \ln(w_d - w_x) + (1 - \theta) \ln[\Pi'_{op}(N_d)] \tag{1}$$

$\theta \in [0, 1]$ and $(1 - \theta)$ are the exogenous Nash bargaining parameters of workers and firms, respectively. Each firm decides its level of total employment, N, and domestic employment, N_d, in the second stage during product market competition. Π_{op} is operating profits per worker.[23] $\Pi'_{op}(N_d)$ represents the marginal profits that accrue to the firm from reaching an agreement with the N_d^{th} worker, hence the firm's surplus. Note that due to the timing of the labor market interaction, the operating profits defined here only involve future production costs and do not take into account a firm's labor market search costs, which are already sunk. Solving this bargaining game derives the following rent-sharing wage specification[24]:

$$w_d = \eta \pi_{op} + w_x \tag{2}$$

where η is the rent-sharing parameter[25] and $\pi_{op} = \frac{\Pi_{op}}{N_d}$ are operating profits per domestic worker.

Alternatively, the Nash bargaining game can also be motivated in the following way:

$$\max_{w_d} \theta \ln(w_d - w_x) + (1 - \theta) \ln[mb]$$

hiring costs in the size of employment expansion. See also Bertola and Garibaldi (2001) and Burdett and Mortensen (1999). Hence, I am not trying to develop anything new here, merely incorporating the idea of convex hiring costs. The convexity of hiring costs is important to the extent that it generates the firm-size wage premium that is observed in the data. If hiring rates are the same across all firms, for example, then wages at each firm would be bargained down and would be the same across all firms. Helpman, Itskhoki, and Redding (2008) develop a nice micro-founded model using screening costs to generate the firm-size wage premium.

[22]The bargaining type here is known as inefficient Nash bargaining or right-to-manage where the firm bargains with workers only on wages; employment is a function of the bargained wages. There are many other types of bargaining models one could choose from such as the efficient Nash bargaining model where bargaining occurs jointly over wages and employment levels or the Stole and Zwiebel (1996) model. However, my goal is not to test any particular bargaining mechanism but rather to generate a rent-sharing wage specification, which any of these models achieve. For more detailed discussions on the right-to-manage model see Abowd and Lemieux (1993) and Estevao and Tevlin (2003).

[23]Note that by operating profits, I specifically mean $pq - wN$ as opposed to $pq - wN - bN_d$. Since search costs bN_d are sunk at the time of bargaining, they do enter into the bargaining interaction. Though I have modeled the timing in this manner, allowing the search costs to be incorporated into the bargaining game would not change the results materially.

[24]See appendix 2 for details.

[25]η is function of θ, and the elasticities of labor demand and operating profit with respect to N. For the sake of simplicity and focus, we assume that these elasticities are negligible and hence that η is exogenous. An interesting extension would be to consider the ramifications of offshoring on an endogenous rent-sharing parameter.

where m is the number of times the firm has to re-search in the labor market to find a replacement worker and so mb is the amount saved by the firm by agreeing on a wage with the current worker. In other words, mb is the replacement cost of a worker. Then, solving similarly to before, we can write domestic wages as $w_d = \eta(mb) + w_x$. Without loss of generality, to simplify ensuing mathematical exposition, I allow $m = \frac{b-w_x}{\eta b}$, which gives:

$$w_d = b \tag{3}$$

Empirically, numerous studies have found evidence of rent-sharing at the sectoral and firm-level in many developed countries.[26] Goos and Konings (2001) summarize that the empirical literature on rent-sharing finds an elasticity of wages with respect to rent between 0.1-0.3 for the US, Canada, UK, and some European countries.

In this model, wages are rising at more productive firms because wages are a share of operating profits per domestic worker, which is rising at more productive firms (see appendix a for proof). Further, as equation (3) demonstrates, the convexities in hiring costs prevent firms from hiring additional workers to bargain down the wages of current workers. This relationship is consistent with strong empirical evidence that more productive/larger firms pay higher wages (see Oi and Idson (1999)) and further that the employer-size wage premium exists even after controlling for skill composition and compensating differentials.[27] Further, conditional on being matched, workers earn the same expected wage across firms, which implies that workers have no incentive to direct their search. Having solved the labor market interaction, firms move on to the second stage where they maximize profits under monopolistic competition with offshoring opportunities.

3.3 Demand

Consumer preferences follow the quasi-linear specification of Melitz and Ottaviano (2008) with generates endogenous markups for firms. This specification is useful for a few reasons. First, endogenous markups allow me to connect cost savings from offshoring to increased profitability for the firm, where the relevant measure of profitability is operating profits per domestic worker.[28] Second, endogenous markups allow me to highlight the competition effect that results from the

[26]Some important papers demonstrating evidence of rent-sharing include Abowd and Lemieux (1993), Blanchflower, Oswald, and Sanfey (1996), Van Reenen (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 (2004) go further and using Canadian labor contracts in manufacturing, find the presence of intra-firm, cross-border rent-sharing.

[27]Numerous papers find this premium even after controlling for a host of alternate stories. As such, the unexplained portion is usually attributed to labor market imperfections such as efficiency wages, search costs, etc that can lead to rent-sharing. Brown and Medoff (1989) is an important work in this area. One of the first papers to use employer-employee matched data, Abowd, Kramarz, and Margolis (1999) find that firm specific effects explain about 21-26% of higher wages, with the remaining explained by worker specific effects.

[28]Under CES preferences, cost savings actually lead to lower operating profits per domestic worker, which is a rather unintuitive result. The results here are not specific to the quasi-linear specification of Melitz and Ottaviano (2008) but would work with any demand system that generates higher markups at more productive firms.

productivity gains from offshoring. In an economy with L units of labor:

$$U = q_x + \left[\rho \int_{i\epsilon I} q_i di\right] - \left[\frac{1}{2}\gamma \int_{i\epsilon I} (q_i)^2 di\right] - \left[\frac{1}{2}\lambda(\int_{i\epsilon I} q_i di)^2\right] \quad (4)$$

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 ρ indexes the substitution between differentiated good i and good X while λ indexes the substitution between aggregate good Y and good X. Lastly, γ indexes the degree of product differentiation amongst the differentiated goods in I. The quasi-linear utility form gives no role for income effects to change the consumption of 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:

$$p_i = \rho - \gamma q_i - \lambda Q_y \quad (5)$$

where Q_y represents total consumption of aggregate good Y. Inverting this function gives demand for good i in this sector:[29]

$$Lq_i = \frac{\rho L}{\lambda M + \gamma} - \frac{L}{\gamma} p_i + \frac{\lambda M}{\lambda M + \gamma} \frac{L}{\gamma} \bar{P}_y \quad (6)$$

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

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

$$p_{max} = \frac{\gamma \rho}{\lambda M + \gamma} + \frac{\lambda M}{\lambda M + \gamma} \bar{P}_y \quad (7)$$

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

4 Benchmark: Limited Offshoring

4.1 Production under Limited Offshoring

As mentioned in the introduction, a move from complete autarky to a fully open economy is not truly testable. Hence, in this section, I consider the benchmark case as one with limited offshoring and later examine the comparative statics of a marginal liberalization on the benchmark equilibrium. In sector Y, there is a continuum of firms, each producing a different good, i[30] In the product market competition stage, firms in sector Y would like to take advantage of cheaper wages abroad. They learn that they must pay a common fixed cost, f_o, that is related to setting up

[29] See Melitz and Ottaviano (2008).

[30] Ensuing discussions are from the point of view of an individual firm and so the subscript i is dropped.

production facilities abroad.

Since demand is linear, and p is decreasing in ϕ (shown in appendix 3a), there exists a unique ϕ^* such that $p(\phi^*) = p_{max}$ and $\Pi(\phi^*) = 0$. Hence, ϕ^* serves as a cut-off to partition firms between those that exit ($\phi < \phi^*$) and those that stay active ($\phi >= \phi^*$) and earn non-negative profits. Since the benefits from offshoring increase with scale, the fixed costs, f_o, partition firms into MNC firms that choose to offshore and purely domestic firms that do not. Appendix 5a shows the existence of and defines the productivity cut-off ϕ_o^*. The following summarizes the separation of firms:

$$\begin{cases} \text{MNC firms:} & \text{if } \phi_o^* < \phi \\ \text{Purely domestic firms:} & \text{if } \phi^* < \phi < \phi_o^* \\ \text{Exiting firms:} & \text{if } \phi < \phi^* \end{cases}$$

Now, the extent of offshoring by a firm, defined as $z^*(\phi)$, is decided by the following condition, where a firm offshores tasks until the marginal cost of the offshored task is the same as the marginal costs of performing that task domestically:

$$\beta t(z^*) w_f = w_d \tag{8}$$

where w_d is solved in equation (11). That is, $\beta t(z) w_f < w_d$ for all tasks $z \in [0..z^*)$ and for task z^* task, the above equality holds, implicitly determining the level of offshoring by a firm in equilibrium. Appendix 4b demonstrates that in equilibrium, more productive firms offshore a higher share of their tasks. The above equation provides a hint of the intuition - because more productive firms pay higher domestic wages, the cost savings from offshoring any given task are also greater and hence they are able to move further up the $t(z)$ schedule.[31]

Having determined the extent of offshoring for a firm, then average wages paid by the firm can be expressed as:

$$w = \beta \bar{t}(z^*) w_f + (1 - z^*) w_d \text{[32]} \tag{9}$$

where $\bar{t}(z^*) = \frac{\int_0^{z^*} t(z)dz}{N}$. Then, total costs are $wN + bN_d + f_o$. Simplifying, marginal costs can be written as $c = \frac{w + w_d(1-z^*)}{\phi}$,[33] where w is expressed in the equation above. Next, by definition, $\pi_{op} = \frac{pq - wN}{N_d}$.[34] Using the above definitions and equations (2) and (9), I can solve for the key variables, π_{op}, w_d, c of a firm:

$$\pi_{op} = \frac{\phi p - \beta \bar{t}(z^*) w_f - (1 - z^*) w_x}{(1 - z^*)(1 + \eta)} \tag{10}$$

[31]This implication that the cost savings from offshoring are higher for more productive firms is directly tied to the assumption that MNCs all face the same foreign wage. See footnote 17 and appendix 1 for more detailed discussions on the implications of relaxing that assumption.

[32]For purely domestic firms, $\bar{t}(z^* = 0) = 0$ and $w = w_d$.

[33]Note that, by definition, $N_d = (1 - z^*)N$. Using this and equation (3) and then taking the derivative with respect to q gives c.

[34]Again, using $N_d = (1 - z^*)N$, gives $\pi_{op} = \frac{\phi p - w}{1 - z^*}$. Then, plugging in for w from equation (9) gives equation (10).

$$w_d = \frac{\eta\phi p - \eta\beta\bar{t}(z^*)w_f + (1-z^*)w_x}{(1-z^*)(1+\eta)} \tag{11}$$

$$c = \frac{2\eta\phi p + (1-\eta)\beta\bar{t}(z^*)w_f + 2(1-z^*)w_x}{\phi(1+\eta)} \tag{12}$$

Setting $z^* = 0$ (meaning no offshoring) for equations (10) - (12) gives the equilibrium equations for purely domestic firms. From the above equations, we learn that c is falling with firm productivity, while π_{op} and w_d are increasing in firm productivity. Further, because of lower marginal costs, more productive firms set lower prices allowing them to achieve higher markups, and produce more (see appendix 3 for proofs).

Now, coming to the firm's problem, firms in sector Y set prices to maximize profits: $\Pi = pq - wN - bN_d - I_x f_x$. Though prices cannot be solved for explicitly in this model, the following function implicitly defines a firm's optimal p:

$$D(p,.) : -\frac{L}{\gamma}p + q + \frac{L}{\gamma}c - q\left[\frac{2\eta}{1+\eta}\right] = 0 \tag{13}$$

where q is determined by equation (6) and c is defined by equation (12) above. This implicit function will be crucial in determining how prices and other key firm-level variables respond to a shock to offshoring costs.

Finally, from equation (13), we can solve for the profit maximizing level of output for a firm as:

$$q = \frac{L}{\gamma}(p-c)\left[\frac{1+\eta}{1-\eta}\right] \tag{14}$$

as long as $\eta < 1$. This is a fairly innocuous constraint as η is the rent-sharing parameter and $\eta = 1$ would imply that workers have complete bargaining power vis-a-vis the firm, an extreme scenario that is not considered here.

4.2 Firm Entry & Exit, Equilibrium under Limited Offshoring

With respect to the entry and exit of firms in sector Y, I follow Melitz (2003). Prior to entry, firms are identical and must pay a sunk 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 models, following Helpman, Melitz, and Yeaple (2004), I assume a pareto distribution to parameterize $G(\phi)$:[35]

$$G(\phi) = 1 - (\tfrac{1}{\phi})^k \quad g(\phi) = \tfrac{k}{\phi}(\tfrac{1}{\phi})^k \tag{15}$$

Having defined ϕ^*, the ex-post distribution of productivities of firms in the market is defined as:

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

Now, I define an average productivity, $\bar{\phi}$, in the following way:

$$z^*(\bar{\phi}) = \frac{\int_{\phi^*_o}^{\infty} z^*(\phi) d\phi}{M} \tag{16}$$

where M is the endogenously determined equilibrium mass of firms in the sector. Hence, $\bar{\phi}$ is the productivity of the firm that has the average level of offshoring in the sector. This is relevant for defining the equilibrium in the economy. Following Melitz (2003), the equilibrium in sector Y is characterized by two conditions. First, the zero-cutoff profit (ZCP) condition asserts that the profits of the marginal entrant should be zero ($\Pi(\phi^*) = 0$). Using this condition, and $\bar{\phi}$ defined above, I solve for average sectoral profits:

$$\bar{\Pi}(\phi^*) = \Pi(\bar{\phi}) \quad (ZCP) \tag{17}$$

where the full derivation is left to appendix 6. In addition to the ZCP condition, the equilibrium structure in this sector is defined by the free entry condition: expected profits from firm entry in sector Y should equal the sunken entry cost, thereby setting the expected payoffs equal to zero, ex-ante. The FE condition can be written as:

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

Appendix 6 demonstrates how both the FE and ZCP conditions behave in the $(\bar{\Pi}, \phi^*)$ space and proves the existence and uniqueness of an equilibrium under sufficient conditions.[36] Finally, to balance trade, I simply assume that exports of the numeraire good pay for the aggregate offshoring bill.

[35] Axtell (2001) shows that pareto accurately captures the distribution of US firms. Using firm level data for eleven European countries, Del Gatto, Mion and Ottaviano (2006) find that "Pareto is a fairly good approximation of the underlying productivity distribution" (p.17) in their data.

[36] One of those conditions is $k > 1$. Axtell (2001) estimates a pareto shape parameter of 1.0-1.1 for US firms using various definitions of firm size. Del Gatto, 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.

5 Comparative Statics

5.1 Firms' Response to a Fall in the Cost of Offshoring

This section examines how firms in sector Y respond to an exogenous fall in the marginal costs of offshoring, which occurs either through a relaxation in the policy constraint, β,[37] or through a fall in foreign wages, w_f.[38] The remainder of this paper discusses the effects of a fall in β, though examining equation (8), a fall in w_f operates in exactly the same way. Appendix 4a shows that as long as a sufficient condition (see equation (28)), which I call the technological slack condition, is satisfied, a fall in β increases offshoring along the intensive margin as any MNC will respond by increasing z^*. The technological slack condition ensures that firms have not hit their technological constraint, above which offshoring becomes technologically too costly to justify, despite a fall in β.[39] If technology was the constraint for most firms, we would not expect a significant increase in the intensive margin of offshoring following a fall in β and/or w_f. However, the empirical analysis shows that the intensive margin of offshoring does rise indicating that policy and wages are more of a constraint than technology.[40] Additionally, there will also be a rise in offshoring along the extensive margin, since the fall in the marginal cost of offshoring elicits the entry of new firms into offshoring (ϕ_o^* falls, see appendix 5b).

Firms can be split up into three categories to simplify the exposition of the comparative statics. The first group of firms are the most productive firms that were offshoring before and continue to offshore after the shock - MNCs. The next set are the new entrants to offshoring.[41] The last set are the firms that remain purely domestic before and after the shock.

Delving deeper, a fall in β reduces costs for MNC firms for two reasons. Let z^*, z_o^* define the level of offshoring for any MNC firm before and after the shock, respectively. Then, a fall in β clearly reduces the cost of marginal tasks $z \in (z^*, z_o^*]$, which is why the firm chooses to offshore these tasks. Additionally, the costs on the inframarginal tasks $z \in [0, z_o^*]$ are also lowered and the larger this set, the higher the cost savings. While MNCs save costs for both reasons, new entrants obviously only benefit on the marginal tasks.

The following propositions summarize the firm-level effects from a fall in policy-related off-

[37] Passage of the FDI Law of 1993 is the empirical analog to a fall in β. See footnote 19.

[38] The sudden depreciation of the Mexican peso in late 1994 significantly lowered the wages of Mexican workers in dollar terms and is the empirical analog to a fall in w_f.

[39] Examining equation (8), which defines the equilibrium level of offshoring by a firm, if β and/or w_f fall, then a firm responds by increasing z^* until the equation is re-balanced. So, in general, a firm will increase its level of offshoring with a fall in the marginal cost of offshoring. However, not necessarily always. For example, if a firm has already offshored much of its activity, $t'(z^*)$ will be very high for that firm - the technological/monitoring costs associated with offshoring senior management are close to infinity and hence a fall in $beta$ and/or w_f will not lead to an increase in offshoring (z^*). At that point, I argue that that firm has hit a technological constraint - meaning the technological/monitoring costs of offshoring that task - $t(z)$ - are the constraining barriers for further offshoring as opposed to policy costs or lack of wages differentials.

[40] The technological slack condition is not necessary to derive the main results of this paper since the productivity effect still exists due to inframarginal cost savings.

[41] Empirically, new entrants seem to account for a very small fraction of increased offshoring. 94% of increased offshoring by US manufacturing MNCs from 1993-97 occurred along the intensive margin, whereas only 6% occurred along the extensive margin.

shoring costs.

<u>**Proposition 1:**</u> ***For new entrants and MNC firms, a fall in β reduces marginal costs (c) and prices (p), while raising markups (μ), operating profits per domestic worker (π_{op}), and domestic wages (w_d). Refer to appendix 7a-e for a proof of proposition 1. See also appendix 1 for additional discussion.***

Regarding proposition 1, as previously discussed, a fall in β reduces costs to MNC firms along both marginally and inframarginally offshored tasks (productivity effect), allowing these firms to lower prices and move down their linear demand schedule and increase their output. Additionally, since demand becomes more inelastic at lower prices, firms are able to increase their markups, μ, leading to higher π_{op}, which are shared with the remaining domestic workers, raising their wages. The combined productivity plus rent-sharing mechanism is labeled the PRS effect.

Next, a fall in β induces some previously purely domestic firms to be able to offshore and their comparative statics are the same for these new entrants as for MNCs.[42] The next proposition captures the effect on the firms which remain purely domestic before and after the shock.

<u>**Proposition 2:**</u> ***A fall in β has externalities on purely domestic firms, reducing their markups (μ), operating profits per domestic worker (π_{op}), and domestic wages (w_d). Refer to appendix 8a-e for a proof of proposition 2.***

Purely domestic firms are impacted negatively by a fall in β. New entrants and MNCs lower prices and steal business, shifting inward the demand schedules of these purely domestic firms. This causes their markups to fall, which translates into lower π_{op} and consequently lower w_d at these firms. I believe that this channel and prediction are contributions to the discussion on the winners and losers from offshoring, which for the most part has ignored these impacts on non-offshoring firms.

<u>**Proposition 3:**</u> ***Offshoring causes domestic wages at MNCs to rise and domestic wages at purely domestic firms to fall, leading to across-firm, within-group wage dispersion.See figure 1.***

Following directly from propositions 1 and 2, this is the main prediction of the model and is consistent with observed trends in within-group wage inequality that have paralleled the recent surge in intermediate goods trade (see Autor, Katz, and Kearney (2008)). See figure 1 for a graphical version of proposition 3 and appendix 1 for a more nuanced discussion of figure 1.

<u>**Proposition 4:**</u> ***For sufficiently small γ, new offshoring opportunities lead to a reallocation of production and labor from purely domestic firms towards new entrants and MNC firms. The***

[42] However, it is ambiguous whether the productivity effect is stronger or weaker at the new entrants compared to MNC firms.

net effect of offshoring on employment at new entrants and MNCs is ambiguous. However, employment at purely domestic firms falls. Refer to appendix 7f and 8f for a proof of proposition 4.

From proposition 1, we know that a fall in β allows new entrants and MNCs to reduce prices, thereby increasing their competitiveness compared to purely domestic firms. This results in a shift in production towards new entrants and MNC firms. Since labor demand at a firm is proportional to production, labor is also reallocated from purely domestic firms towards new entrants and MNCs, causing employment to fall at purely domestic firms. However, the effect on employment at new entrants and MNCs is ambiguous though as the employment gain due to expansion is offset by the direct loss of jobs due to offshoring.

In summary, a fall in offshoring costs allows new entrants and MNC firms to gain a competitive advantage vis-a-vis purely domestic firms. This leads to diverging effects on markups, operating profits per domestic worker, and domestic wages. Furthermore, the business-stealing effect reallocates production and employment from purely domestic firms to new entrants and MNCs. Becker and Muendler (2008) find supporting evidence for Germany. Using employer-employee linked data, they find that expanding MNCs retain more jobs than competitors without foreign expansion. Similarly, the empirical analysis here finds no differential outcomes in employment between offshoring and non-offshoring firms, consistent with the channel described above.

5.2 Sector Level Analysis

An analysis of the effect of marginal liberalization requires an examination of the ZCP and FE conditions. While the FE condition remains unchanged, the ZCP condition is affected by offshoring. Appendix 9 demonstrates that the ZCP curve must shift up in response to increased offshoring and leads to a higher ϕ^* and higher $\bar{\Pi}$ in the offshoring equilibrium.[43] Let the initial cutoff productivity be denoted as ϕ_a^*. Then, firms with productivity $\phi_a^* < \phi < \phi^*$, must exit the industry, which indicates that for these firms, the negative business-stealing effect drives them out of business.

To conclude, consider how sector-level variables respond to increased offshoring. Average prices in sector Y, $\bar{P}_y$, decrease with offshoring for two reasons: (1) prices decrease at new entrants and MNC firms and (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 also increases.

The effect of marginal liberalization on employment in sector Y is ambiguous. This is consistent with empirical evidence offered by Amiti and Wei (2005), who find that depending on the degree of industry disaggregation, services and materials offshoring have small and ambiguous overall effects on domestic employment. To see why the effect is ambiguous in this model, I write

[43] This can also be seen from equation (7), which reveals that falling $\bar{P}_y$ lowers p_{max}, which confirms that ϕ^* must be higher in the new equilibrium.

L_y in the following way:

$$L_y = \int_{\phi^*}^{\phi_o^*} \frac{q(\phi)}{\phi} d\phi + \int_{\phi_o^*}^{\infty} \frac{(1 - z^*(\phi))q(\phi)}{\phi} d\phi \tag{19}$$

where the first term represents employment at purely domestic firms in sector Y and the second term represents employment at MNCs in sector Y. The effects of offshoring can now be decomposed into two main channels. The first is the direct effect of the loss of offshored jobs at MNCs, which is represented by a rise in $z^*(\phi)$ in the second term above. The second channel, as seen in proposition 4, operates through a reallocation of labor from less productive to more productive firms. In equation (19) this reallocation is comprised of four effects: (1) a fall in $q(\phi)$ in the first term representing the contraction of purely domestic firms; (2) a rise in ϕ^* in the first term representing the exit of the least productive firms; (3) a fall in ϕ_o^* representing new entrants entering into offshoring; and (4) a rise in $q(\phi)$ in the second term representing expansion by MNCs. If the expansionary effect of new entrants and MNCs can offset the loss of jobs at less productive firms plus the direct loss of jobs, the net employment effect could actually be positive.

6 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, which are defined as the combination of a single consolidated US entity (parent) with at least 10% ownership in a foreign enterprise (foreign affiliate).[44] The BEA data is the most comprehensive data available for US-based MNCs and their foreign affiliates, containing annual financial and operating numbers for the years 1984-2004.[45] The BEA also conducts more detailed benchmark surveys for the years 1982, 1989, 1994, 1999, and 2004. The number of observations (parent US firms) from 1984-2004 is 31,684 US manufacturing firms and 43,509 US manufacturing and services firms. During the more relevant period of 1993-2001, there are approximately 1,654 and 2,323 firms per year in manufacturing and manufacturing plus services, respectively.

I begin by constructing a panel over the years 1993-1997 and 1997-2001. First, although the universe contains US parent firms in all sectors, the main estimations in this paper focus on a restricted sample of parent manufacturing firms, which is defined by SIC codes 200-399. However, as I discuss in section 8.1, the main results are robust to including services and wholesale and retail firms. Second, a concordance between NAICS and SIC codes allows me to handle the shift from SIC to NAICS codes for industry classification from 1999 onwards. A major strength of the BEA data is that it allows for more precise measurement of cross-border vertical production sharing. Most datasets only capture total FDI by a firm, making it difficult to distinguish between FDI

[44] The consolidated US entity may itself be owned by a foreign firm - approximately 10% of the sample.

[45] Actually, the data goes back to 1982, with an additional collection in 1977. However, from my observations, the quality and consistency of the data is focused on the years 1984-2004.

for market access (horizontal FDI) versus FDI for vertical production sharing. The BEA dataset separates affiliate sales between sales within the firm and sales outside the firm. Hence, I proxy cross-border vertical production by constructing intrafirm affiliate sales 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; and (3) sales from foreign affiliates to other affiliates in other foreign countries. By aggregating over all affiliates, I am able to capture the total amount of intrafirm affiliate sales for a US parent firm. I am implicitly assuming that trade amongst affiliates and the parent is part of the vertical production process while trade to non-affiliated customers is for market access.[46] The measure constructed here is similar to the ones used by Grossman and Rossi-Hansberg (2006) and Harrison and McMillan (2008) to capture vertical activity by multinationals.

As discussed, the BEA data is extremely useful for identifying vertical activities, which is critical to understanding the effects of offshoring. On the other hand, the data does not contain information on arms length transactions, preventing measurement of offshore outsourcing (see footnote 1). This means that some results in this paper could in fact be understating actual magnitudes. One important weakness of the BEA data is the lack of information on workers' characteristics at the firm level, which does not allow me to perfectly identify the PRS effect from a skill composition story. I perform additional analyses to deal with this issue as best as possible. The analyses are described in section 8. Key firm-level variables of interest are sales, employment, intrafirm affiliate sales, R&D expenditures, total employment compensation, and operating profits per domestic worker. Appendix 10 describes variable definitions.

7 Estimation

7.1 Background

To test the main predictions from the model, I use events in Mexico as an exogenous shock to the costs of offshoring to Mexico. First, the 1993 Foreign Investment Law (FIL), which was tied to NAFTA, was passed in December of 1993. Mexico's attitude towards foreign investment had historically been one of caution. Prior to 1973, Mexico did not have an investment law. 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 and comprehensive code, which turned out to be 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, thus adding arbitrariness to the process. During the late 1980s, as the Mexican economy was liberalizing in many areas, the Salinas government realized the importance of foreign investment and passed a 1989 regulation on the 1973 FIL, thereby aiming to make foreign ownership in Mexico easier. However, the 1989 regulation had little credibility behind it as

[46] Intrafirm affiliate sales over total affiliate sales was approximately 20% in 1982, rising to 35% in 2004.

the Mexican Supreme Court could have deemed it unconstitutional.[47] On the other hand, the 1993 FIL enacted by the legislature was more legally binding. The new law streamlined and expedited administrative procedures related to foreign investment, minimized the exercise of discretionary powers by Mexican authorities, and increased foreign ownership limits from 49% to 100% in all manufacturing and some service industries. Further, it was requisite reform for Mexico's participation in NAFTA. Arguably, the passage of NAFTA served more as a credibility device than for particular investment reforms itself. Together with NAFTA, the 1993 FIL signaled credibly to the international business community that Mexico was open for foreign investment.

Second, the Mexican peso crisis at the end of 1994 would have also encouraged increased offshoring from the US to 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 decline of nearly 60%. This significant depreciation lowered the cost of Mexican labor in dollar terms. 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 (see Verhoogen 2008). Although there are a variety of theories regarding the causes of the depreciation, it was unexpected as the black market and official exchange rates coincided before and after (Verhoogen 2008).

Figures 3 and 4, illustrate that these two episodes elicited a strong increase in intrafirm affiliate sales by Mexican affiliates of US manufacturing MNCs. Figure 3 depicts that total intrafirm affiliate sales from Mexico jumped noticeably from 1995-97. A similar pattern exists even after controlling for general sales growth. Figure 4 demonstrates a sharp increase from 1995-96 in intrafirm affiliate sales from Mexican affiliates as a share of total global sales of US parent firms.[48] I consider the period 1993-97 to examine the effects of the two episodes on US parent firm-level variables.

7.2 Empirical Methodology

The theoretical model suggests that wages would diverge across firms that would likely be able to take advantage of a fall in the marginal cost of offshoring to Mexico (MNCs), versus firms that would be unlikely to do so (purely domestic firms). However, the BEA dataset only contains US MNC firms. In this section, I make a slight modification to the theory to allow for the theoretical predictions to better connect to the empirical methodology.

Let there be two Southern countries; a generic Latin American country and Mexico. Assume that offshoring to each requires identical fixed costs. Introduce now a few asymmetries in the marginal costs of offshoring to the two locations. First, due to differences in regulations, define β_m and β_{la} for Mexico and the Latin American country, respectively, with $\beta_m > \beta_{la}$.[49] Second,

[47] See Uriarte (1995).

[48] From here on, when referring to the share of intrafirm sales of Mexican affiliates, I mean $\frac{\text{Intrafirm Mexican affiliate sales of the US parent}}{\text{Total global sales of the US parent}}$.

[49] For example, Chile had more relaxed rules on foreign investment compared to Mexico through the 1970s and 80s. Alternatively (or additionally), I could also define w_m and w_{la} such that $w_{la} < w_m$. Since β and w_f come in multiplicatively into the marginal cost of offshoring, either of these assumptions by themselves or combined generate

define separate $t(z)$ schedules - $t_m(z)$ and $t_{la}(z)$, respectively, such that for some $0 < \bar{z} < 1$, the following holds:

$$\begin{aligned} t_m(z) = t_{la}(z) \quad if z <= \bar{z} \\ t_m(z) < t_{la}(z) \quad if z > \bar{z} \end{aligned} \tag{20}$$

This setup captures the notion that distance matters for some tasks but not others. In particular, from the second line, distance matters more for tasks that are increasingly non-routine while according to the first line, distance does not matter for routine tasks. The logic presented here is consistent with the earlier discussion on the $t(z)$ schedule and that $t(z)$ is increasing in z.

Comparing the marginal cost curves of offshoring to Mexico and the Latin American country, $\beta_m t_m(z) w_f$ and $\beta_{la} t_{la}(z) w_f$, respectively. Since $\beta_{la} < \beta_m$, it is cheaper to offshore low z tasks to the Latin American country. Next, as long as $t_{la}(z)$ is increasing sufficiently faster than $t_m(z)$, I can define a $\bar{\bar{z}} > \bar{z}$ such that the marginal cost of offshoring the $\bar{\bar{z}}$ task is the same between the two regions. However, the MNC firm that decides to offshore exactly $\bar{\bar{z}}$ tasks will not yet move some offshoring to Mexico because of the fixed costs associated with establishing an offshoring presence in Mexico. In comparison, the MNC firm has already paid the fixed costs of offshoring to the Latin American country. Rather, define another cut-off ϕ_m^* such that a firm with this productivity level offshores exactly $z_m > \bar{\bar{z}}$ tasks and is indifferent between offshoring all $[0..z_m]$ tasks only to the Latin American country versus paying additional fixed costs and moving $[\bar{\bar{z}}..z_m]$ tasks to Mexico. Hence, in the pre-shock equilibrium, MNC firms with $\phi_o^* < \phi < \phi_m^*$ offshore only to the Latin American country, whereas the most productive MNC firms $\phi_m^* < \phi$ offshore to both Latin America and Mexico.[50] See figure 2 for a graphical representation of the above discussion.

With a fall in the marginal cost of offshoring to Mexico, the model would predict that the firms which already have a presence in Mexico (that is, have already paid the fixed costs of entry) are likely to take advantage and expand their offshoring to Mexico. Meanwhile, firms offshoring to Latin America but not Mexico are unlikely to take advantage of this shock. This is borne out by the data. Approximately 94% of the increase in offshoring from 1993-97 occurred along the intensive margin, illustrating an increase in offshoring by firms already in Mexico. Only 6% was due to the extensive margin, or the entry of new firms into Mexico. To test the prediction on wages, I first exclude firms who do not offshore to Mexico or anywhere in Latin America, leaving me with a sample of 387 firms. Then, I separate firms into treatment and control groups. The treatment group is defined as firms that have an offshoring presence in Mexico at the beginning of the period. The control group is defined as firms that offshore to other countries in Latin America at the beginning of the period, but that do not offshore to Mexico. In addition to this control group, I try a more general comparison group in the robustness section. Table 1 shows that treatment firms are on

the same results. The only difference would be in the exact determination of the productivity cut-off that ensues.

[50] What about firms which offshore only to Mexico? This setup does not predict such an outcome. A more complicated model where firms differ on the tasks required for production would address this issue. However, empirically, less than 10% of the treatment firms in the sample offshore only to Mexico. While considering this case could be an interesting extension, I did not think it useful for the scope of this paper.

average larger along many different measures than control firms, which is predicted from the model. However, this poses some econometric issues that I address in the next section.

Bertrand, Duflo, and Mullainathan (2004) raise an important issue in difference-in-differences estimates. They show that using many years of pre- or post-crisis data without taking into account serial correlation across periods could understate the standard error on the coefficient estimates. By using just one year of pre-crisis data and one year post-crisis, i.e. 1993 and 1997, I "ignore time-series information"; Bertrand et al (2004) find that this strategy performs well. So, in preparing the data for estimation, I keep only the first and last year and balance the sample.

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; $Treatment_{ij}$ is a dummy variable that is turned on when 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 when the year is 1997 and turned off when the year is 1993; $\gamma_j * Post_t$ captures industry trends over time; and ε_{ijt} is a mean-zero disturbance. Differencing the above equation between 1993 and 1997 gives the following equation:

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

Equation (22) is the main estimating equation. The outcome variables of interest are intrafirm sales share from Mexico, operating profits per US worker, average domestic wages, and employment at the US parent firm.

7.3 Main Results

The results for equation (22) are displayed in table 2, columns 1-4, which show that estimates for β_1 are statistically significant at least at the 10% level for all of the outcome variables except log employment. For example, the share of intrafirm affiliate sales from Mexico rose 0.7% more for treatment firms than for control firms during the 1993-97 time period. This difference confirms that US firms already with a presence in Mexico are better able to take advantage of a fall in the marginal costs of offshoring to Mexico. Further, the fact that treatment firms responded by increasing offshoring indicates that these firms have not hit their technological wall as discussed in the theoretical section.[51] Next, columns 2 and 3 indicate that operating profits per US worker and average domestic wages increased 9.4% and 6.0%, respectively, more for treatment firms than control firms with the magnitudes indicating economic significance. These initial results confirm the main theoretical prediction that average domestic wages increased at firms that were positioned to take advantage of lower offshoring costs relative to ones that were not. In particular, average domestic wages rose about 2.0% at treatment firms and fell about 3.5% at control firms.

[51] The technological wall, as mentioned in section 1.5.1, is the point at which the technological costs of offshoring become binding and hence any reduction in non-technological costs will not elicit increased offshoring.

Interestingly, there is no statistically significant difference between the changes in employment at treatment firms versus control firms. This evidence, which is consistent with proposition 4, contradicts the notion that offshoring disproportionately hurts employment at firms that offshore.

There are two reasons that these results could be understating the magnitude of the effect of offshoring on average domestic wages. First, as defined in the introduction, offshoring includes both offshore outsourcing and cross-border intrafirm production sharing. However, this empirical analysis only captures the latter since data on offshore outsourcing is not available. The effects could be even larger if offshore outsourcing is also taken into account.[52] Second, this analysis considers only intrafirm affiliates sales from Mexico. Despite Mexico's importance as a source of offshoring, it still constitutes only about 5% of global cross-border intrafirm affiliate sales at US MNCs.

7.4 Additional Analyses

In this section, I strengthen the empirical work along several dimensions. First, the main analysis uses parent firms offshoring to Latin America but not to Mexico as the comparison group. Anticipating that there may be characteristics unique to Latin America that could bias the comparison. To mitigate these concerns, I consider a broader comparison group, which includes parent firms that offshore to any other developing country but not to Mexico.[53] The results are provided in row 2 of table 3 and reveal that changing comparison groups does not make a material difference.

Another concern is related to the inclusion of only US manufacturing firms in the main sample. As stated earlier, this was done because the quality of data, notably for offshoring, is better for manufacturing firms than for service firms. However, the exclusion of services firms introduces the following concern. Imagine a firm which is originally classified as manufacturing but then offshores most or all of its manufacturing operations. Being left with mainly headquarter activities in the US, this firm would be classified as services in the later period and therefore would be dropped from my original sample, leading to selection bias. To address this concern, I re-run the main estimation with manufacturing and service parent firms and also with manufacturing, service, and wholesale/retail parent firms. The results are presented in table A.1 of the appendix and are mostly consistent with the main results. The magnitudes of the coefficients are slightly smaller compared to the main results (except for skill ratio) and are statistically significant for all the outcome variables except average domestic wages, where it falls slightly outside of 90% confidence.

Next, the differences between treatment and control firms observed in table 1 is an issue. Treatment firms are larger than control firms by sales, employees, and R&D, likely indicating that treatment firms are more productive. It is realistic to expect that larger and more productive firms could have reacted to shocks differently and subsequently bias estimated coefficients. Mex-

[52] Antras and Helpman (2004) cite BEA data to suggest "that the growth of foreign outsourcing by US firms might have outpaced the growth of their foreign intrafirm sourcing." However, as they write, the evidence is suggestive, not conclusive.

[53] Developing countries are defined by the World Bank as countries with GDP per capita less than $11,455 as of 2007.

ico's unique proximity to the US could also have caused treatment firms to respond differently to shocks than control firms, again biasing 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 the cost of offshoring.[54] 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:

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

where $Treatment_{ij}$ includes firms that had a presence in Mexico in the base year. The base year for the 1993-97 period is 1993 and for the 1997-01 period is 1997. $Period_t$ is a dummy variable that takes the value of 0 for the 1993-97 period and 1 for the 97-01 period. Table 3, row 1 presents the estimation results for equation (23). A negative coefficient on the interaction term reveals that β_{93-97} is larger than β_{97-01} and implies 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 in row 1 indicate that the estimates for β_1 are negative and statistically significant for all the outcome variables. In particular, we can interpret the results in the following way: operating profits per US worker and average domestic wages increased 17.2% and 10.0% more for treatment firms than control firms during the 1993-97 period versus the 1997-01 period. These results indicate that the FDI law and the peso crisis caused differential outcomes in the 1993-97 period between treatment and control firms that was greater than generic differences in background trends.

While the above exercise helps mitigate the concerns regarding differences between treatment and control firms, is there something unique about the 1997-01 period? In order to offer more general evidence, I run the following equation, which is similar to equation 21, but with year dummies for 1984-2004 rather than a post dummy.

$$y_{ijt} = \beta_0 + \beta_1 Treatment_{ij} * Year_t + \beta_2 Year_t + \beta_3 Treatment_{ij} + \gamma_j * Year_t + \epsilon_{ijt} \tag{24}$$

The coefficient β_1 represents the amount that the outcome variable is higher at treatment firms compared to control firms in a given year. To offer support for the main findings, β_1 should rise around 1994 and continuing rising for a few years thereafter before leveling off. The estimated coefficients for β_1 are shown in figures 5-8 for four outcome variables of interest. The dotted lines in the figures represent the 90% confidence interval. In figures 5 and 6, using two different measures of offshoring, there is a sharp increase in the offshoring differential in 1994 that continues until 1997. After 1997, there appears to be an immediate drop in the offshoring differentials, followed by a return to 1997 levels by 2003. Figure 7 exhibits a similar but weaker trend for operating profits per US worker. Finally, figure 8 offers a convincing story for average domestic wages. The

[54] I pick the 1997-01 period (as opposed to the 1989-93 period) because I think it would be a cleaner placebo. Gradual economic liberalization efforts had begun in Mexico during the late 80s and early 90s.

differential between treatment and control firms increased significantly in 1994 and leveled off a few years later. Furthermore, the coefficient is statistically significant only from approximately 1994-98. Together, these offer convincing evidence that outcome variables trended differently for treatment and control firms during 1993-97 when compared to other periods.

Again, the issue raised by Bertrand et al. (2004) should be addressed regarding the estimation of equation (24). Since many years of pre- and post-crisis data are used in this specification, I must account for potential serial correlation across periods. One method is to cluster the standard errors at the firm-level, which imposes the restriction that the error term is correlated for a firm across time. However, the standard errors actually became smaller under this specification. Therefore, the results presented here take the more conservative estimate by using the robust option.

8 Alternative Channels

An alternate story could be posed, in which offshoring increases average domestic wages at offshoring firms due to compositional changes in domestic employment. Feenstra and Hanson (1996) suggest that offshoring of jobs from North to South would increase the skill composition of workers in the North since the relatively least-skilled jobs would be sent abroad. Continuing this logic, offshoring could lead to higher average domestic wages at the parent firm simply because the cheapest (least-skilled) jobs have been offshored. Hence, perhaps the wage differentials could be explained by a skill composition effect. Ideally, firm-level worker characteristics would allow for perfect identification between the two channels. However, since the BEA dataset does not contain information on the skill composition of employees at the parent firm, I 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. I then use the BEA data to identify the top eight product (industry) categories for each parent firm. I combine the data to derive a weighted average skill composition variable for each US parent firm (see appendix 10). Column (5) of table 1 reveals that skill composition also increased more for treatment firms than for control firms under both comparison groups, providing evidence in support of the skill composition effect.

The evidence thus far indicates that offshoring caused wages to diverge at the firm-level for two reasons. First, I find evidence that the profitability of offshoring firms increased following an exogenous shock. Combined with evidence of rent-sharing found in the literature, this implies that offshoring increased domestic wages though the PRS channel put forth in this paper. Second, I find evidence that the skill composition of labor also increased at offshoring firms following the shock. The increase in skill composition would also lead to an increase in domestic wages at these offshoring firms.

Next, I offer an additional pieces of evidence that is consistent with the PRS story. Recalling equation (2), which indicates that the PRS effect should be stronger in industries with higher rent-sharing, I extend equation (22) to:

$$\Delta w_{ij} = \beta_0 + \beta_1 Treatment_{ij} + \beta_2 Treatment_{ij} * RS_j + \gamma_j + \varepsilon_{ij} \tag{25}$$

where RS_j captures the extent of rent-sharing in industry j. A positive and significant estimate for β_2 would indicate that wages increased more for treatment firms versus control firms in industries with a higher-degree of rent-sharing. To estimate industry-level rent-sharing, I use CPS data from 1993 and regress an individual's wage on a host of observable characteristics and industry dummies. The observable characteristics include state, gender, and marital status dummies, age, age-squared, occupation type, and years of schooling. 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 4. These results indicate that the estimation for β_2 from the equation above is positive and statistically significant, under both comparison groups, giving lending further support for the PRS hypothesis put forth in this paper.

As a caveat, the coefficients on the industry dummies from the first-stage can also be interpreted as capturing unobservable worker characteristics rather than rent-sharing. The literature on inter-industry wage differentials is mixed with evidence suggesting both explanations (see Rycx and Tojerow 2007). Nevertheless, it is reassuring that the results from estimating equation (25) are consistent with the PRS mechanism.

As the empirical evidence provided here offers support for both channels, I perform back-of-the-envelope calculations to get a sense of the relative magnitudes of the two effects and confirm the sensibility of the findings. The empirical literature on rent-sharing has found a wage elasticity with rents of 0.1-0.3. Multiplying the mid-point of these findings by .094 (from row 1, column 2, table 2) results in .019. This indicates that approximately 30% (1.9 out of 6.0) of the increased spread in average domestic wages between treatment and control firms during the period 1993-97, can be explained by the PRS mechanism. The remaining 70% could be explained by the composition effect.

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 US, foreign affiliates could charge their US parent higher prices for intermediate inputs in order to reduce the firm's overall tax burden. Such a transfer pricing story would show up as increased intrafirm affiliate sales, but without implications for productivity gains. Rather, it would merely reflect changes in book-keeping. However, corporate tax rates in Mexico remain unchanged during the 1993-97 period. Further, state corporate tax rates in the US remain unchanged or even fell during this period; with Vermont being the only exception.[55] Hence, it is unlikely that corporate tax rates could be leading to changes in transfer pricing to the US parent firm. Additionally, corporate tax rates in most other countries either remain unchanged or even fell. This refutes the possibility that transfer pricing could be in effect from Mexican affiliates to other foreign country affiliates of the firm.

[55] State and country corporate tax data reflect the top tax rate and come from the University of Michigan's World Tax Database.

9 Conclusion

This paper investigates the idea of offshoring as technology, with a focus on trying to understand the productivity effects of offshoring on firm-level domestic wages and employment.

This paper finds evidence that US MNCs more likely to take advantage of a new offshoring opportunity experienced a rise in relative profitability and average domestic wages during 1993-97 (shock period). This differential change was greater during the 1993-97 period than other periods without similar shocks to offshoring costs. In addition, the differential change was greater for firms in industries with ostensibly higher levels of rent-sharing. Meanwhile, the empirical analysis finds no evidence of greater employment loss due to offshoring between treatment and control firms.

The evidence described above is consistent with offshoring impacting wages and employment through a productivity and rent-sharing mechanism. With heterogeneous firms, only certain firms are able to take advantage of offshoring opportunities. Offshoring enables these firms to experience productivity gains, which raises profitability and domestic wages at these firms. The productivity gain allows them to become more competitive and steal business at the expense of firms unlikely to enter into or expand their offshoring. This productivity-fueled expansion helps offset the direct loss of domestic jobs to offshoring, while the business stealing effect leads non-offshoring firms to contract, which lowers their domestic wages and employment.

The findings in this paper challenge conceptions that offshoring most negatively affects wages and employment at firms that offshore. Rather, this research suggests that offshoring should be viewed as a technology, enhancing productivity and competitiveness and offers new evidence on winners and losers from offshoring. Workers at MNCs performing non-routine tasks could benefit the most from offshoring while workers at purely domestic firms, interestingly, could be hurt due to the loss in competitiveness.

What then about the workers at MNCs whose jobs were offshored? It would be interesting to know if these workers were re-hired at expanding MNC firms at higher wages or if they had to take an outside job at a much lower wage. This avenue of empirical work would be useful for developing better targeted policies aimed at helping workers who are hurt by offshoring. Further, this paper assumes that workers are homogeneous. However, offshoring could affect different types of workers in different ways. For example, offshoring could have heterogeneous effects on the bargaining power of workers depending on the type of tasks that they perform. Extending the theory and empirics to consider these additional heterogeneous effects on workers would be an interesting direction for future research.

Appendix

Appendix 1

In this section, I discuss the potential effects of endogenizing the foreign wage, w_f. First, it is important to note that endogenizing w_f does not affect any of the propositions detailed in the paper. However, it could affect the top end of the post-shock wage profile drawn in figure 1.

Taking a step back, firms choose to offshore to lower their marginal costs on tasks. Note that the cost differential between performing any task z at home versus abroad is simply $sN(w_d - \beta t(z) w_f)$. In the model, since all domestic firms face the same w_f abroad, the cost differential is driven by differences in w_d across firms and so more productive firms enjoy higher cost savings by offshoring any particular task z. Hence, in the benchmark equilibrium, more productive firms are predicted to offshore a greater portion of their tasks. Then, following a shock that lowers the marginal cost of offshoring, more productive firms experience greater cost savings due to the inframarginal effect. This greater efficiency boost translates into larger profitability gains and domestic wage gains at more productive MNCs, which can be seen in figure 1 (see appendix 7g for proof). What would happen to the post-shock wage profile at the top end if w_f is endogenized? I look at three cases below.

(1) Assume that foreign wages are endogenized but all MNCs still face the same foreign wage. One way to endogenize would be to introduce common search costs b_f in the foreign market. So while there would be wage bargaining in the foreign market, all MNCs would bid down the wage of foreign workers to their replacement cost and $w_f = b_f$ for all foreign workers employed at MNCs. However, notice that cost savings from offshoring in this scenario are similar to the situation described in the paragraph above and hence the post-shock wage profile would look the same. The only difference is that foreign wages would also rise with offshoring and so the optimal level of offshoring (z^*) for each firm will be lower and the cutoffs (ϕ^*, ϕ_o^*) would be higher.

(2a) Now, let us examine the case where MNCs face different foreign wages. Assume that labor search costs in the foreign market are $b_f(\phi)$ and are convex like in the domestic labor market, $b'_f(\phi) > 0$. Similarly to equation (3), MNCs are able to bargain foreign wages down to replacement costs such that any MNC faces $w_f(\phi) = b_f(\phi)$. Now, the cost savings from offshoring any task z for a firm with productivity ϕ are:

$$sN(w_d - w_f) = sN(\frac{b_d}{-}\frac{b_f}{)})$$

where d denotes domestic variables and f denotes foreign variables. Then, the derivative of the above expression with respect to ϕ is positive if domestic search costs are more convex than foreign search costs for any MNC: $b'_d(\phi) > b'_f(\phi)$. In which case, we are back to figure 1.

(2b) What if $b'_d(\phi) \leq b'_f(\phi)$ in the above scenario? That is, search costs are as convex or more convex in the foreign labor market compared to the domestic labor market. In this case, cost savings will actually be higher for less productive MNCs and this will cause less productive firms to offshore more in the benchmark equilibrium. Then, following a fall in the marginal cost of offshoring, cost savings will accrue more to the firms who have higher inframarginally offshored tasks - the least productive firms. Hence, they will witness the greatest efficiency gain as well as a higher profitability and wage boost leading to the domestic wage profile converging at the top rather than diverging as illustrated in figure 1.

Appendix 2

To solve the bargaining problem in equation (1), first show that $\Pi'_{op}(N_d) = \pi_{op}$. Begin by defining operating profits simply as $\Pi_{op} = pq - wN$. Next, remember the production function, $q = \phi N$. Also, by definition, the measure of domestic workers is $N_d = (1 - z^*)N$. Then, operating profits can be re-written as $\Pi_{op} = \frac{N_d(\phi p - w)}{1 - z^*}$. Then, to find the marginal profitability of a domestic worker:

$$\Pi'_{op}(N_d) = \frac{\phi p - w}{1 - z^*} + (\frac{N_d}{1 - z^*})\frac{d(\phi p - w)}{dN_d} \tag{26}$$

To resolve $\frac{d(\phi p - w)}{dN_d}$, substitute equation (9) and re-write $\phi p - w$ as:

$$\phi p - w = \frac{\phi p(1 - \eta) - (1 - \eta)\beta\bar{t}(z^*)w_f - (1 - z^*)w_x}{1 + \eta}$$

Now, taking the derivative of the above equation with respect to N_d:

$$\frac{d(\phi p - w)}{dN_d} = \frac{\phi(1 - \eta)}{1 + \eta}\frac{dp}{dq}\frac{dq}{dN_d} = \frac{\phi(1 - \eta)}{1 + \eta}\frac{\gamma}{L}\phi(1 - z^*)$$

where $\frac{dp}{dq} = \frac{\gamma}{L}$ from demand equation (6). Then, for sufficiently large L, $\frac{d(\phi p - w)}{dN_d}$ becomes very small. Going back to equation (26):

$$\Pi'_{op}(N_d) = \frac{\phi p - w}{1 - z^*} = \pi_{op} \tag{27}$$

The previous calculations allow the bargaining game to be re-written as:

$$\max_{w_d} \theta \ln(w_d - w_x) + (1 - \theta) \ln[\pi_{op}]$$

Now, see the solution for the right-to-manage model in Abowd and Lemieux (1993) and Estevao and Tevlin (2003). Rearranging their solution leads to equation (2).

Appendix 3

Proofs for how firm-level variables behave by firm productivity. 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) $\frac{dN}{d\phi} > 0$; (f) $\frac{d\Pi}{d\phi} > 0$; (g) $\frac{d\pi_{op}}{d\phi} > 0$; (h) $\frac{dw_d}{d\phi} > 0$.

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

To solve for $\frac{dp}{d\phi}$, remember the function D(p, ϕ) - equation (13) - which implicitly solves for the optimal price for the firm:

$$D(p, \phi) : -\frac{L}{\gamma}p + q + \frac{L}{\gamma}\left[\frac{2\eta\phi p + (1 - \eta)\beta\bar{t}(z^*)w_f + 2(1 - z^*)w_x}{\phi(1 + \eta)}\right] - q\frac{\eta}{1 + \eta} = 0$$

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

$$\frac{\partial D}{\partial \phi} = \frac{L}{\gamma}\left[\frac{\phi \frac{dz^*}{d\phi}[(1-\eta)\beta\bar{t}'(z^*)w_f - 2w_x] - [(1-\eta)\beta\bar{t}(z^*)w_f + 2(1-z^*)w_x]}{\phi^2(1+\eta)}\right] < 0$$
$$\frac{\partial D}{\partial p} = -\frac{L}{\gamma}\left[\frac{2(1-\eta)}{(1+\eta)}\right] < 0$$
$$\frac{dp}{d\phi} < 0$$

To sign $\frac{\partial D}{\partial \phi}$, let us examine the two terms in the numerator within the brackets. Looking at the first term, appendix 4b shows that $\frac{dz^*}{d\phi} > 0$. Also, since we assume that the technological slack condition (equation (28)) holds, we can sign the term in brackets, in the first term, as negative. The bracketed second term is clearly positive. Hence, the entire expression is negative.

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

Taking the derivative of c with respect to ϕ using equation (12) gives and substituting for $\frac{dp}{d\phi}$ from above gives:

$$\frac{dc}{d\phi} = (\frac{2\eta}{1+\eta})\frac{dp}{d\phi} + \frac{\phi \frac{dz^*}{d\phi}[(1-\eta)\beta\bar{t}'(z^*)w_f - 2w_x] - [(1-\eta)\beta\bar{t}(z^*)w_f + 2(1-z^*)w_x]}{\phi^2(1+\eta)}$$
$$\frac{dc}{d\phi} = (\frac{2}{1+\eta})\frac{dp}{d\phi} < 0$$

Since we already know from part (a) that $\frac{dp}{d\phi} < 0$, the above can also be signed as negative. So far, I have shown that marginal costs and prices are lower at more productivity firms.

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

$$\frac{d\mu}{d\phi} = \frac{dp}{d\phi} - \frac{dc}{d\phi} = \frac{dp}{d\phi} - (\frac{2}{1+\eta})\frac{dp}{d\phi} = (\frac{\eta - 1}{1+\eta})\frac{dp}{d\phi} > 0$$

The above inequality holds true as long as $\eta \in (0, 1)$. Thus, markups are higher at more productive firms.

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

Taking the derivative of equation (6) with respect to ϕ and again plugging in for $\frac{dp}{d\phi}$:

$$\frac{dq}{d\phi} = -\frac{L}{\gamma}\frac{dp}{d\phi} > 0$$

Part (a) already showed that $\frac{dp}{d\phi} < 0$, so clearly the above must be positive.

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

For active firms, the production function is $q = \phi N$. Then, $N = \frac{q(\phi)}{\phi}$. Taking the derivative with respect to ϕ:

$$\frac{dN}{d\phi} = \frac{(\phi\frac{dq}{d\phi}) - q}{\phi^2} = \frac{(-\phi\frac{L}{\gamma}\frac{dp}{d\phi}) - q}{\phi^2}$$

Next, plugging in for $\frac{dp}{d\phi}$ and setting $z^* = 0$ (just to simplify the exposition), gives:

$$\frac{dN}{d\phi} = \frac{(\frac{L}{\gamma}\frac{w_x}{\phi(1-\eta)}) - q}{\phi^2}$$

Then, finally plugging in for q from equation (14):

$$\frac{dN}{d\phi} = \frac{\frac{L}{\gamma}[(1-\eta)w_x - \phi(p-c)(1+\eta)^2]}{\phi^3(1+\eta)(1-\eta)}$$

For sufficiently small η or sufficiently large w_x, the above is positive, which is consistent with the empirically robust finding in the literature that more productive firms have larger employment.

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

$\Pi = q\mu$. 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.

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

Note that $\pi_{op} = \frac{\Pi}{N_d} = \frac{q\mu}{N_d} = \frac{\phi\mu}{1-z^*}$. Now taking the derivative of this expression with respect to ϕ gives:

$$\pi_{op} = \frac{\phi\mu}{1-z^*}$$
$$\frac{d\pi_{op}}{d\phi} = \frac{[(\mu+\phi(\frac{d\mu}{d\phi}))(1-z^*)]+[(\phi\mu)(\frac{dz^*}{d\phi})]}{(1-z^*)^2} > 0$$

Since we know that $\frac{d\mu}{d\phi} > 0$ and $\frac{dz^*}{d\phi} > 0$, the above is clearly positive.

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

Taking the derivative of equation (2) with respect to ϕ and using the result from part (f) gives:

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

Appendix 4

(a) Show that $\frac{dz^*}{d\beta} < 0$:

I want to demonstrate that a marginal liberalization led to more offshoring by MNC firms. Equation (8) implicitly defines the equilibrium level of offshoring by a MNC firm. Substituting equation (11) for w_d, gives the following implicit function:

$$F(z^*,.) = (1-z^*)(1+\eta)\beta t(z^*)w_f - \eta\phi p + \eta\beta\bar{t}(z^*)w_f - (1-z^*)w_x = 0$$

From the implicit function theorem, $\frac{dz^*}{d\beta} = -\frac{\frac{\partial F}{\partial \beta}}{\frac{\partial F}{\partial z^*}}$:

$$\frac{\partial F}{\partial \beta} = (1-z^*)(1+\eta)t(z^*)w_f + \eta\bar{t}(z^*)w_f > 0$$
$$\frac{\partial F}{\partial z^*} = \eta\beta\bar{t}'(z^*)w_f + w_x + (1-z^*)(1+\eta)\beta t'(z^*)w_f - (1+\eta)\beta t(z^*)w_f$$
$$\frac{dz^*}{d\beta} < 0$$

Note, that if $\frac{\partial F}{\partial z^*} > 0$ is satisfied, which I call the technological slack condition, then $\frac{dz^*}{d\beta} < 0$. The technological slack condition is:

$$\eta\beta\bar{t}'(z^*)w_f + w_x + (1-z^*)(1+\eta)\beta t'(z^*)w_f - (1+\eta)\beta t(z^*)w_f > 0 \quad (28)$$

This sufficient condition implies that technological constraints are not binding. It holds if technological costs, $t(z^*)$, are small or if the cost savings are large enough through the other parameters such as high w_x. Hence, as long as the technological slack condition holds, a fall in β induces an increase in offshoring by MNC firms.

(b) Show that $\frac{dz^*}{d\phi} > 0$:

I want to demonstrate that more productive MNCs offshore more in equilibrium. Again, from the implicit function theorem, $\frac{dz^*}{d\phi} = -\frac{\frac{\partial F}{\partial \phi}}{\frac{\partial F}{\partial z^*}}$:

$$\frac{\partial F}{\partial \phi} = -\eta p - \eta\phi\frac{dp}{d\phi} < 0$$
$$\frac{\partial F}{\partial z^*} = \eta\beta w_f\bar{t}'(z^*) + w_x + (1-z^*)(1+\eta)\beta w_f t'(z^*) - (1+\eta)\beta w_f t(z^*)$$

Then, as long as the technological slack condition is satisfied we get that $\frac{\partial F}{\partial z^*} > 0$. Hence, we can conclude that $\frac{dz^*}{d\phi} > 0$.

Appendix 5

(a) Show the existence of and define ϕ_o^*:

The sunk costs of offshoring, f_o, pin down a productivity cut-off, ϕ_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, first note that offshoring, by saving on wages, allows a firm to lower its marginal costs, c (i.e. receive an efficiency boost). Then, for a firm with productivity ϕ, $c_o(\phi) < c(\phi)$, where $c_o(\phi)$ represents the firm's marginal costs, with offshoring and $c(\phi)$ represents the firm's marginal costs with no offshoring. Define $\tilde{\phi}$ such that $c(\tilde{\phi} = c_o(\phi)$. Hence, we know that $c(\tilde{\phi} < c(\phi)$ and using the proof from appendix 3b, we can conclude that $\tilde{\phi} > \phi$ (this is where the term "productivity effect" comes from).

From appendix 3f, we know that firms with higher productivity achieve higher profits. So we can define ϕ_o^* as the firm that is indifferent between offshoring and achieving an efficiency boost and not offshoring:

$$\Pi_{op}(\tilde{\phi}(\phi_o^*)) - f_o = \Pi(\phi_o^*) \quad (29)$$

(b) Show that a marginal liberalization shifts the cutoff ϕ_o^* down:

A fall in β provides an even greater efficiency boost from offshoring, which is proved in appendix 7b. Hence, the original marginal firm is making positive profits in the new equilibrium after a fall in β. For any given ϕ, $\tilde{\phi}(\phi)$ is higher than before. Then, for the equality in equation (29) to hold, ϕ_o^* must fall allowing for new entrants.

Appendix 6

Show the existence and uniqueness of equilibrium:

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

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

Hence, the FE condition is increasing and accelerating in the $(\phi^*, \bar{\Pi})$ space (as long as $k > 1$). Next, in order to analyze the ZCP condition, recall equation (14), which defines profit maximizing output for the firm:

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

Then, substituting this expression for q into the ZCP condition from equation (17):

$$\begin{aligned}&\bar{\Pi} = \Pi(\bar{\phi}) = q(\bar{\phi})\mu(\bar{\phi}) - f_o\\&\bar{\Pi} = \Pi(\bar{\phi}) = \tfrac{L}{\gamma}[\mu(\bar{\phi})]^2(\tfrac{1+\eta}{1-\eta}) - f_o\\&\tfrac{d\Pi(\bar{\phi})}{d\bar{\phi}} = 2\tfrac{L}{\gamma}\tfrac{d\mu(\bar{\phi})}{d\bar{\phi}}\mu(\bar{\phi})(\tfrac{1+\eta}{1-\eta}) > 0\end{aligned}$$

The last inequality follows from appendix 2c, where it is proved that $\frac{d\mu(\bar{\phi})}{d\bar{\phi}} > 0$. Next, we can show that $\frac{d\bar{\phi}}{\phi^*} > 0$ by examining equation (16). First, by definition, M (the number of active firms) falls as ϕ^* rises. Also, the total amount of offshoring (the numerator of equation (16)) increases with ϕ^* because as ϕ^* rises, there is less competition and marginal non-offshoring firms decide to offshore (ϕ_o^* falls). Now, putting it all together:

$$\frac{d\bar{\Pi}}{d\phi^*} = [\frac{d\Pi(\bar{\phi})}{d\bar{\phi}}][\frac{d\bar{\phi}}{\phi^*}] > 0$$

Hence, both the FE and the ZCP curves are increasing in the $(\phi^*, \bar{\Pi})$ space, which is insufficient to determine the existence or uniqueness of equilibrium. To that end, I would like to sign the second derivative of the ZCP curve with respect to ϕ^*:

$$\bar{\Pi}''(\phi^*) = \Pi''(\bar{\phi})[\frac{d\bar{\phi}}{\phi^*}]^2 + [\frac{d\Pi(\bar{\phi})}{d\bar{\phi}}]\bar{\phi}''(\phi^*) \quad (30)$$

To sign the above expression, I first find $\Pi''(\bar{\phi})$:

$$\Pi''(\bar{\phi}) = 2\frac{L}{\gamma}(1+\eta)[\mu\mu''(\bar{\phi}) + (\frac{d\mu(\bar{\phi})}{d\bar{\phi}})^2] < 0$$

Using the results from appendix 3a and 3b, we get that for sufficiently small w_x, the above second derivative is negative. Next, I need to find $\bar{\phi}''(\phi^*)$. To do that, I assume there is a continuous, one-to-one relationship between $\bar{\phi}$ and ϕ^*, define the inverse function $\phi^*(\bar{\phi})$, and the distribution of $\bar{\phi}$ as $\psi(\bar{\phi})$. Then, we can find the distribution of $\bar{\phi}$ in the following way:

$$\psi(\bar{\phi}) = \varphi[\phi^*(\bar{\phi})]{\phi^*}'(\bar{\phi})$$

Next, taking the derivative of both sides with respect to $\bar{\phi}$ and re-arranging, gives:

$$\psi'(\bar{\phi}) = \varphi'(\phi^*)[{\phi^*}'(\bar{\phi})]^2 + \varphi[\phi^*(\bar{\phi})]{\phi^*}''(\bar{\phi})$$
$${\phi^*}''(\bar{\phi}) = \frac{\psi'(\bar{\phi}) - [\varphi'(\phi^*)[{\phi^*}'(\bar{\phi})]^2]}{\varphi[\phi^*(\bar{\phi})]}$$

Since $\varphi(\phi^*)$ is a pareto distribution, $\varphi'(\phi^*) < 0$. Further, from above, we also know that ${\phi^*}'(\bar{\phi}) > 0$. Hence, as long as the distribution of $\bar{\phi}$ is sufficiently downward sloping, we get that ${\phi^*}''(\bar{\phi}) < 0$. Since $\bar{\phi}$ has a pareto distribution, the sufficient condition would simply be that the shape parameter for $\psi(\bar{\phi})$ is greater than or equal to the shape parameter for $\varphi(\phi^*)$. Finally, since there is a one-to-one mapping between ϕ^* and $\bar{\phi}$, we can conclude that $\bar{\phi}''(\phi^*) > 0$.

Under these sufficient conditions, plugging back into equation (30), gives $\bar{\Pi}''(\phi^*) < 0$. Meaning, the ZCP condition is increasing but decelerating in the $(\phi^*, \bar{\Pi})$ space. Meanwhile, the FE condition is increasing and accelerating. The final step to confirm the uniqueness and existence of an equilibrium requires that the FE condition at $(\phi_{min} = 1)$ must be below the ZCP at $(\phi_{min} = 1)$, which can be satisfied if f_e, γ are small enough or L is large enough.

Appendix 7

Want to show that (a) $\frac{dp^M}{d\beta} > 0$; (b) $\frac{dc^M}{d\beta} > 0$; (c) $\frac{d\mu^M}{d\beta} < 0$; (d) $\frac{d\pi^M_{op}}{d\beta} < 0$; (e) $\frac{dw^M_d}{d\beta} < 0$; (f) $\frac{dq^M}{d\beta} < 0$. Before beginning, I define the cost savings (CS) from a fall in β as the partial of equation (**??**) with respect to β:

$$(1-\eta)\bar{t}(z^*)w_f + \frac{dz^*}{d\beta}[(1-\eta)\beta\bar{t}'(z^*)w_f - 2w_x]$$

The first term captures the savings that accrue on inframarginal tasks (already offshored). The second term captures the savings on new marginal tasks that are offshored due to the fall in β. Clearly, the second term must be non-negative by definition. If the technological wall has been hit, then $\frac{dz^*}{d\beta} = 0$ and the whole term becomes zero. If not, then by appendix 4a, $\frac{dz^*}{d\beta} < 0$ and the whole term is necessarily positive. Hence, we can definitely sign CS as positive.

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

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

$$D(p^M, \beta) : -\frac{L}{\gamma}p^M + q^M + \frac{L}{\gamma}\left[\frac{2\eta\phi p^M + (1-\eta)\beta\bar{t}(z^*)w_f + 2(1-z^*)w_x}{\phi(1+\eta)}\right] - q^M\frac{2\eta}{1+\eta} = 0$$

From the implicit function theorem, $\frac{dp^M}{d\beta} = -\frac{\frac{\partial D}{\partial \beta}}{\frac{\partial D}{\partial p^M}}$:

$$\begin{aligned} \frac{\partial D}{\partial \beta} &= \frac{L}{\gamma}\frac{CS}{\phi(1+\eta)} + (\frac{1-\eta}{1+\eta})\frac{\partial q^M}{\partial \beta} > 0 \\ \frac{\partial D}{\partial p^M} &= -\frac{L}{\gamma}\frac{2(1-\eta)}{(1+\eta)} < 0 \\ \frac{dp^M}{d\beta} &= \frac{CS}{2\phi(1-\eta)} > 0 \end{aligned}$$

Now, $\frac{\partial q^M}{\partial \beta} > 0$ captures the partial effect of the demand curve shifting in for all firms as the price level falls in sector Y and can be seen by examining equation (6). For the rest of this proof, I assume that $\frac{\partial q}{\partial \beta}$ is small relative to the first expression in $\frac{\partial D}{\partial \beta}$ and thus drop it. Dropping it does not change the results, but does simplify the exposition.

(b) Show that $\frac{dc^M}{d\beta} > 0$:

Taking the derivative of equation (12) with respect to β and plugging in for $\frac{dp^M}{d\beta}$ from part (a):

$$\begin{aligned} \frac{dc^M}{d\beta} &= \frac{[2\eta\phi\frac{dp^M}{d\beta} + CS]}{\phi(1+\eta)} \\ \frac{dc^M}{d\beta} &= \frac{CS}{(1+\eta)\phi(1-\eta)} > 0 \end{aligned}$$

(c) Show that $\frac{d\mu^M}{d\beta} < 0$:

Comparing (a) and (b):

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

Again, this holds since $\eta \in (0, 1)$.

(d) Show that $\frac{d\pi^M_{op}}{d\beta} < 0$:

Taking the derivative of equation (10) with respect to β and plugging in for $\frac{dp^M}{d\beta}$:

$$\frac{d\pi^M_{op}}{d\beta} < \frac{(\phi\frac{dp^M}{d\beta} - [\frac{CS}{1-\eta}])(DEN) + (1+\eta)\frac{dz^*}{d\beta}(NUM)}{(DEN)^2} = \frac{(-\frac{CS}{2(1-\eta)})(DEN) + (1+\eta)\frac{dz^*}{d\beta}(NUM)}{(DEN)^2} < 0$$

where DEN and NUM indicate the denominator and numerator, respectively, of the expression in equation (10), both of which are positive. Again, knowing that $\frac{dz^*}{d\beta} < 0$ from appendix 4a, we can sign the whole expression above as negative.

(e) Show that $\frac{dw_d^M}{d\beta} < 0$:

Taking the derivative of equation (2) with respect to β and plugging in from part (d) gives:

$$\frac{dw_d^M}{d\beta} = \eta \frac{\partial \pi_{op}^M}{\partial \beta} + w_x < 0$$

(f) Show that $\frac{dq^M}{d\beta} < 0$:

Taking the derivative of equation (6) with respect to β:

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

New entrants and MNCs lower prices more than purely domestic firms: compare appendix 7a with 8a. Hence, $\frac{dp^M}{d\beta} > \frac{d\bar{P}_y}{d\beta}$ implying that for sufficiently small γ, $\frac{dq^M}{d\beta} < 0$ and quantity/production increases with falling offshoring costs (positive "business-stealing effect" for MNCs and new entrants). Since employment is a linear function of q, it follows that there is some reallocation of labor towards these firms as well.

While the business stealing effect leads to a reallocation of production and labor towards new entrants and MNCs, what about the net effect on labor? Note that domestic employment can be expressed as: $N_d = \frac{q(1-z^*)}{\phi}$. While we have showed that q increases for new entrants and MNCs, we also know that offshoring has increased for these firms (see appendix 4a) and hence the net effect is ambiguous.

(g) Show that a fall in β leads to cost savings which increase in the productivity of the firm:

In equilibrium, two firms with productivity ϕ_1 and ϕ_2 offshore $[0..z^*(\phi_1)]$ and $[0..z^*(\phi_2)]$ tasks, respectively, with $\phi_1 < \phi_2$. When β falls, both firms save equally on each inframarginal task $z \in [0..z^*(\phi_1)]$. Now, assume that firm 1 increases offshoring and saves on marginal tasks $z \in [0..z_o^*(\phi_1)]$. Now there are two cases to examine:

Case 1: $z_o^*(\phi_1) < z^*(\phi_2)$ - $z \in [z^*(\phi_1)..z_o^*(\phi_1)]$ represents marginally offshored tasks for firm 1 but inframarginally offshored tasks for firm 2. Firm 2 accrues a larger cost savings on these tasks than firm 1 with a fall in β. Why? Firm 2 was paying $\beta t(z) w_f$ for each of these tasks before whereas firm 1 was paying $w_d(\phi_1)$ for each of these tasks. Clearly $w_d(\phi_1) < \beta t(z) w_f$ because otherwise firm 1 would have offshored these tasks previously. Since both firms have the same cost for these tasks in the new equilibrium, the cost savings are higher for firm 2 in each of these tasks $z \in [z^*(\phi_1)..z_o^*(\phi_1)]$. In addition, firm 2 saves on additional inframarginally and marginally offshored tasks.

Case 2: $z_o^*(\phi_1) > z^*(\phi_2)$ - Same as in case 1, firm 2 saves more on each task $z \in [z^*(\phi_1)..z_o^*(\phi_2)]$. Now, tasks $z \in [z^*(\phi_2)..z_o^*(\phi_1)]$ are marginally offshored by both firms. However, clearly firm 2 saves more on each of these tasks as it was paying $w_d(\phi_2) > w_d(\phi_1)$ for each task. Additionally, firm 2 also saves on additional marginally offshored tasks up to $z_o^*(\phi_2)$.

Since cost savings are higher at more productive MNCs from a fall in β, then the increase in markups, operating profits per domestic worker, and domestic wages are also greater at more productive MNCs.

Appendix 8

Want to show that (a) $\frac{dp^D}{d\beta} > 0$; (b) $\frac{dc^D}{d\beta} > 0$; (c) $\frac{d\mu^D}{d\beta} > 0$; (d) ambiguously $\frac{d\pi^D_{op}}{d\beta} > 0$; (e) $\frac{dw^D_d}{d\beta} > 0$; (f) $\frac{dq^D}{d\beta} > 0$.

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

To solve for $\frac{dp^D}{d\beta}$, remember the function $D(p^D, \beta)$ - equation (13) - which implicitly solves the optimal price for the purely domestic firm:

$$D(p^D, \beta) : -\frac{L}{\gamma}p^D + q^D + \frac{L}{\gamma}\frac{2(\eta\phi p^D + w_x)}{\phi(1+\eta)} - q^D\frac{2\eta}{1+\eta} = 0$$

From the implicit function theorem, $\frac{dp^D}{d\beta} = -\frac{\frac{\partial D}{\partial \beta}}{\frac{\partial D}{\partial p^D}}$:

$$\begin{aligned} \frac{\partial D}{\partial \beta} &= (\tfrac{1-\eta}{1+\eta})\frac{\partial q^D}{\partial \beta} \\ \frac{\partial D}{\partial p^D} &= -\frac{L}{\gamma}\frac{2(1-\eta)}{(1+\eta)} \\ \frac{dp^D}{d\beta} &= \frac{\frac{\partial q^D}{\partial \beta}}{2\frac{L}{\gamma}} > 0 \end{aligned}$$

where the last inequality holds because $\frac{\partial q^D}{\partial \beta} > 0$, which can be seen by examining equation (6). The intuition behind this partial effect is that a fall in the marginal cost of offshoring lowers the price level in sector Y and hence shifts in the demand curve for purely domestic firms.

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

Setting $z^* = 0$ in equation (12) and then taking the derivative with respect to β and substituting in for $\frac{dp}{d\beta}$ from part (a) gives:

$$\frac{dc^D}{d\beta} = \frac{2\eta}{1+\eta}\frac{dp^D}{d\beta} > 0$$

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

Comparing (a) and (b):

$$\begin{aligned} \frac{d\mu^D}{d\beta} &= \frac{dp^D}{d\beta} - \frac{dc^D}{d\beta} \\ \frac{d\mu^D}{d\beta} &= (\tfrac{1-\eta}{1+\eta})\frac{dp^D}{d\beta} > 0 \end{aligned}$$

for $\eta < 1$, a constraint already discussed in section 4.1.

(d) Show $\frac{d\pi_{op}^D}{d\beta} > 0$:

Setting $z^* = 0$ in equation (10) and then taking the derivative with respect to β and substituting in for $\frac{dp}{d\beta}$ gives:

$$\frac{d\pi_{op}^D}{d\beta} = \frac{\phi \frac{dp^D}{d\beta}}{1+\eta} > 0$$

(e) Show $\frac{dw_d^D}{d\beta} > 0$:

Taking the derivative of equation (2) with respect to β:

$$\frac{dw_d^D}{d\beta} = \eta \frac{d\pi_{op}^D}{d\beta} + w_x > 0$$

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

Taking the derivative of equation (6) with respect to β:

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

For purely domestic firms, prices fall less than for MNC firms: compare appendix 7a with 8a. Hence, $\frac{dp^D}{d\beta} < \frac{d\bar{P}_y}{d\beta}$ implying that for sufficiently small γ, $\frac{dq^D}{d\beta} > 0$ and quantity decreases for purely domestic firms ("business-stealing effect"). Since employment at the firm is a linear function of q, it follows that employment at a purely domestic firm should fall as a result of this business-stealing effect.

Appendix 9

Describe the post-liberalization equilibrium in the ($\phi^*, \bar{\Pi}$) space:

I want to show that the ZCP condition shifts up following liberalization (i.e. show that $\frac{d\bar{\Pi}(\phi^*)}{d\beta} < 0$). Again, from equation (17), we have that:

$$\frac{d\bar{\Pi}(\phi^*)}{d\beta} = [\frac{d\bar{\Pi}(\bar{\phi})}{d\beta}]$$

Now, from appendix 6, we already have that:

$$\Pi(\bar{\phi}) = \frac{L}{\gamma}[\mu(\bar{\phi})]^2(\frac{1+\eta}{1-\eta}) - f_o$$
$$\frac{d\Pi(\bar{\phi})}{d\beta} = 2\frac{L}{\gamma}\mu(\bar{\phi})\frac{d\mu}{d\beta}(\frac{1+\eta}{1-\eta}) < 0$$

Note that from equation (16), $\bar{\phi}$ represents an offshoring firm. Hence, the last inequality follows directly from appendix 7c, where we found that $\frac{d\mu^M}{d\beta} < 0$. The ZCP curve shifts up following liberalization because the direct effect of offshoring leads to cost savings and increased profitability at the average firm (defined by $\bar{\phi}$). This is equivalent to higher average industry profits, holding ϕ^* fixed.

Appendix 10

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

Intrafirm affiliate sales	(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.
Global parent sales	Total sales as reported for the US parent, deflated by the producer price index.
Share of intrafirm affiliate sales	Intrafirm affiliate sales/Global parent sales.
R&D	R&D expenditures as reported for the US parent, deflated by the producer price index.
Domestic employees	Total number of domestic 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 domestic 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,1 - Sales,8	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.

Table A.1 - Dependent variable is differenced between 1997 and 1993

	Δ Offshoring Share[a]	Δ Log(Op Profits/ US Employee)	Δ Log(Avg Wages)	Δ Log(Domestic Employment)	Δ Skill Ratio
Treatment (1)	0.072***	0.068	0.052	-0.049	0.141*
	(0.018)	(0.041)	(0.036)	(0.051)	(0.084)
# Observations	456	449	447	456	454
Treatment (2)	0.065***	0.070*	0.052	-0.067	0.130*
	(0.017)	(0.041)	(0.033)	(0.053)	(0.082)
# Observations	524	516	515	525	524

(a) Intrafirm sales of Mexican affiliates divided by total global sales of US parent

(1) Sample includes US manufacturing and service firms
(2) Sample includes US manufacturing, service, and wholesale and retail firms

* 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

Note: Treatment refers to firms which had an offshoring presence in Mexico in 1993 and control refers to firms which offshored to other Latin American countries but not Mexico in 1993.

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Tables and Figures

Table 1 - 1993 Summary Statistics

	Full Sample	Treatment	Control	Difference
Num of aff countries	5.8 (0.23)	18.0 (1.11)	8.4 (0.51)	9.7*** (1.21)
Num of affiliates	9.6 (0.59)	36.1 (3.19)	12.5 (0.98)	23.6*** (3.28)
Log (global sales)	12.58 (0.04)	14.37 (0.12)	13.59 (0.11)	0.78*** (0.16)
Log (US employees)	7.32 (0.04)	9.10 (0.10)	8.29 (0.10)	0.80*** (0.14)
Log (R&D)	8.71 (0.06)	10.69 (0.15)	9.52 (0.13)	1.17*** (0.20)
Log (op. profits-per-US worker)	4.92 (0.02)	4.93 (0.04)	4.96 (0.06)	-0.04 (0.07)
Labor skill ratio	1.22 (0.03)	2.05 (0.09)	1.47 (0.08)	0.58*** (0.12)
Log (average wage)	3.89 (0.01)	3.95 (0.02)	3.88 (0.03)	0.08** (0.04)
Intrafirm aff. sales share†	0.07 (0.00)	0.15 (0.04)		
# Observations	1582	190	197	

† Intrafirm sales of Mexican affiliates divided by total global sales of US parent
** statistically significant at 5% level
*** statistically significant at 1% level

Note: Full sample includes all US manufacturing MNCs (not just treatment and control groups). Treatment refers to US manufacturing firms which had an offshoring presence in Mexico in 1993 and control refers to US manufacturing firms which offshored to other Latin American countries but not Mexico in 1993.

Table 2 - Dependent variable is differenced between 1997 and 1993

	Δ Offshoring Share[a]	Δ Log(Op Profits/ US Employee)	Δ Log(Avg Wages)	Δ Log(Domestic) Employment)
Treatment (1)	0.075***	0.094**	0.060*	-0.032
	(0.019)	(0.043)	(0.037)	(0.052)
# Observations	387	384	381	387

(a) Intrafirm sales of Mexican affiliates divided by total global sales of US parent

(1) Comparison group is MNCs which offshore to Latin America 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

Note: Sample includes US manufacturing firms only.

Table 3 - Dependent variable is differenced between 1997 and 1993

	Δ Offshoring Share[a]	Δ Log(Op Profits/ US Employee)	Δ Log(Avg Wages)	Δ Log(Domestic) Employment)	Δ Skill Ratio
Treatment (1)	0.075***	0.094**	0.060*	-0.032	0.138*
	(0.019)	(0.043)	(0.037)	(0.052)	(0.077)
# Observations	387	384	381	387	385
Treatment (2)	0.069***	0.074*	0.055*	-0.021	0.133*
	(0.018)	(0.042)	(0.035)	(0.050)	(.080)
# Observations	405	402	397	405	405

(a) Intrafirm sales of Mexican affiliates divided by total global sales of US parent

(1) Comparison group is MNCs which offshore to Latin America but not Mexico, in 1993
(2) Comparison group is MNCs which offshore to other middle income developing 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

Note: Sample includes US manufacturing firms only.

Table 4 - Dependent variable is differenced separately between 1997 and 1993 and 2001 and 1997

	Δ Offshoring Share[a]	Δ Log(Op Profits/ US Employee)	Δ Log(Avg Wages)
Interact (1)	-0.112***	-0.119*	-0.100*
	(0.026)	(0.073)	(0.060)
Treatment	0.082***	0.053	0.046
	(0.020)	(0.049)	(0.045)
Period	0.043**	-0.033	0.114**
	(0.019)	(0.061)	(0.050)
# Observations	598	596	594
Interact (2)	-0.110***	-0.108*	-0.099*
	(0.027)	(0.068)	(0.057)
Treatment	0.071***	0.035	0.029
	(0.020)	(0.048)	(0.042)
Period	0.040**	-0.083	0.121***
	(0.020)	(0.057)	(0.046)
# Observations	634	626	630

(a) Intrafirm sales of Mexican affiliates divided by total global sales of US parent

(1) Comparison group is MNCs which offshore to Latin America but not Mexico, in 1993/97
(2) Comparison group is MNCs which offshore to other middle income developing 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

Note: Sample includes US manufacturing firms only.

Table 5 - Dependent variable is differenced between 1997 and 1993

	Δ Log(Avg Wages)
Treatment (1)	-0.008
	(0.031)
Treatment*Rent-Sharing	0.437*
	(0.263)
# Observations	369
Treatment (2)	-0.012
	(0.031)
Treatment*Rent-Sharing	0.443*
	(0.257)
# Observations	387

(1) Comparison group is MNCs which offshore to Latin America but not Mexico, in 1997
(2) Comparison group is MNCs which offshore to other middle income developing 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

Note: Sample includes US manufacturing firms only.

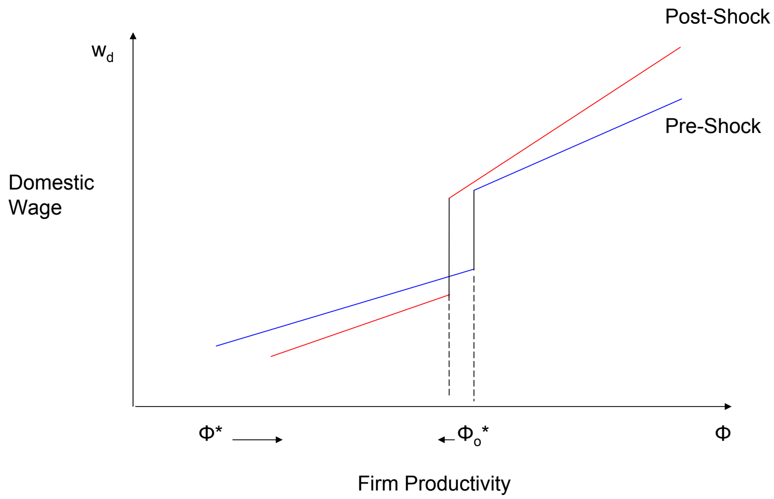

Figure 1: Domestic wage changes following a fall in the marginal cost of offshoring

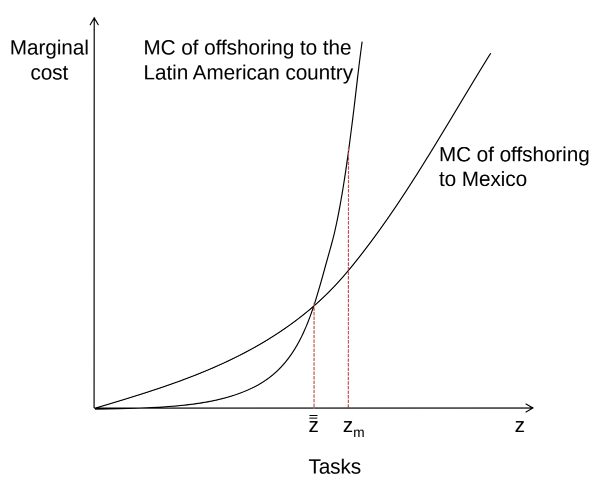

Figure 2: The respective marginal costs of offshoring to Mexico and a generic Latin American country

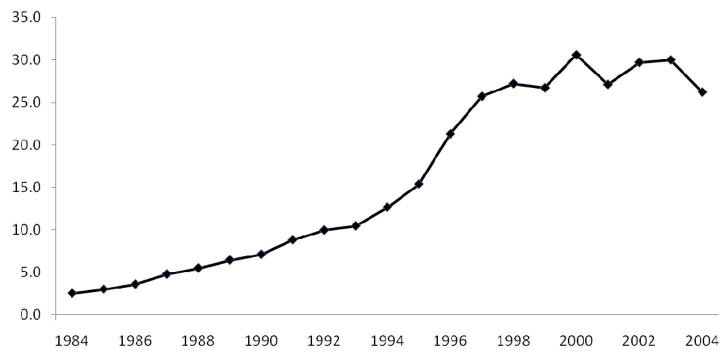

Figure 3: Intrafirm Mexican affiliate sales of US manufacturing MNCs ($Bn)

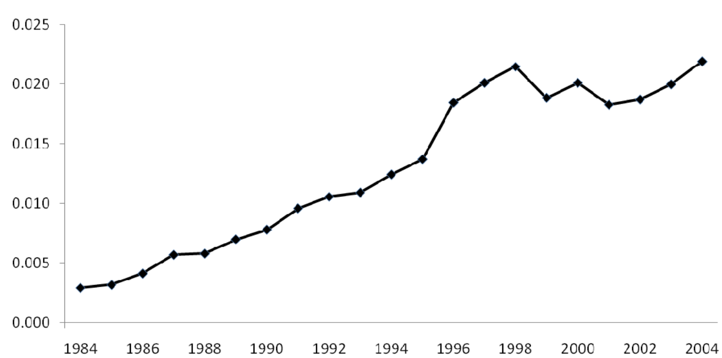

Figure 4: $\frac{\text{Intrafirm Mexican affiliate sales of the US parent}}{\text{Total global sales of the US parent}}$ for US manufacturing MNCs

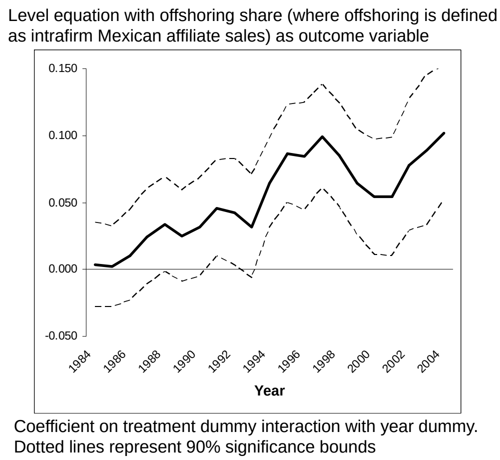

Figure 5: Coefficient for treatment-year interaction from equation 24 where the dependent variable is $\frac{\text{Intrafirm Mexican affiliate sales of the US parent}}{\text{Total global sales of the US parent}}$. Dotted lines represent 90% confidence interval.

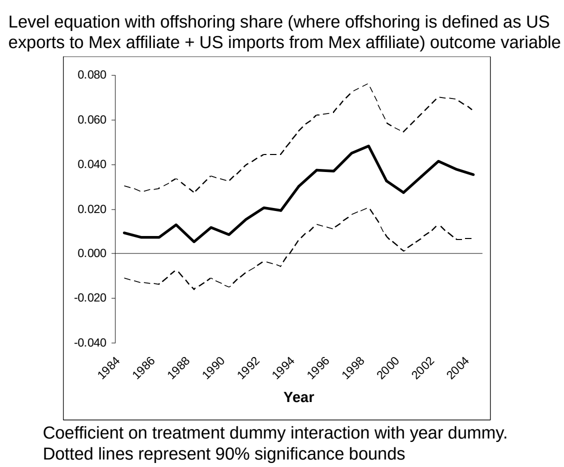

Figure 6: Coefficient for treatment-year interaction from equation 24 where the dependent variable is $\frac{\text{Intrafirm sales between US parent and Mexican affiliate}}{\text{Total global sales of the US parent}}$. Dotted lines represent 90% confidence interval.

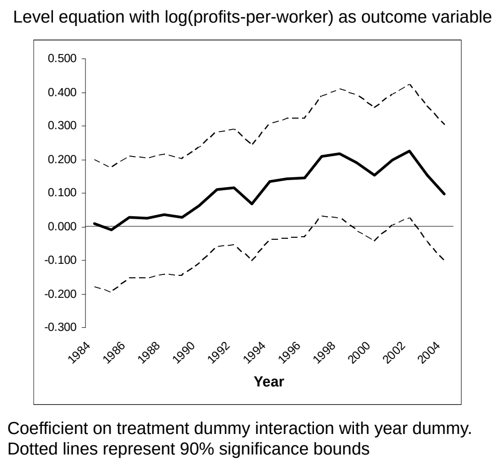

Figure 7: Coefficient for treatment-year interaction from equation 24 where the dependent variable is ln(operating profits per US worker). Dotted lines represent 90% confidence interval.

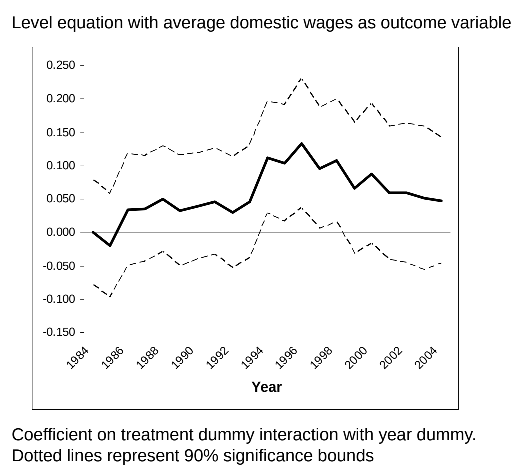

Figure 8: Coefficient for treatment-year interaction from equation 24 where the dependent variable is ln(average domestic wages). Dotted lines represent 90% confidence interval.