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Tracking Wage Inequality Trends with Prices and Different Trade Models

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Abstract

Mexican wage inequality rose following Mexico's accession to the General Agreement on Tariffs and Trade/World Trade Organization in 1986. Since the mid-1990s, however, wage inequality has been falling. Since most trade models suggest that output prices can affect factor prices, this paper explores the relationship between output prices and wage inequality. The rise of inequality can be explained by the evolution of the relative price of skill-intensive goods relative to unskilled-intensive goods, but these prices flattened by 1999 and thus cannot explain the subsequent decline in wage inequality. An alternative trade model with firm heterogeneity driven by variations in the relative price of tradable relative to non-tradable goods can explain the decline in wage inequality. The paper compares this model's predictions with Mexican inequality statistics using data on output prices, census data, and quarterly household survey data. In spite of the model's simplicity, the model's predictions match Mexican variables reasonably well during the years when wage inequality fell.

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Tracking Wage Inequality Trends with Prices and Different Trade Models: Evidence from Mexico[1]

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I. Introduction

Does globalization increase or reduce inequality? Intense debate surrounding globalization's effect on wage inequality followed Wood's (1997) suggestion that inequality fell in East Asia but rose in Latin America following liberalization. Wood's (1997) argument inspired many prominent papers that sought to explain why liberalization in a labor-abundant country would result in rising inequality. During the 2000s, however, inequality fell throughout Latin America, suggesting that the link between globalization and inequality is not well understood.

When reviewing this literature, Goldberg and Pavcnik (2007) show that the relationship between globalization and inequality is subtle and complex. Contributing factors include outsourcing (Feenstra and Hanson 1997), skill-biased technological change (Esquivel and Rodriguez-Lopez 2003), rising numbers of educated workers (Lopez-Acevedo 2006), exchange rate movements (Verhoogen 2008), income support policies (Esquivel et al. 2010), and the rise of China (Chiquiar and Ramos-Francia 2008 and Dussel Peters and Gallagher 2013). Changes in relative output prices, the variables suggested by neoclassical trade theory, remain relatively unexplored.

The goal of this paper is to assess the role of relative output price changes in driving inequality. Most trade models focus on one of two relative output price measures. The first classifies products by factor intensity. In the globalization-and-wages literature, the relative price of skill-intensive goods would be the most relevant. The Stolper-Samuelson theorem, a standard result in neoclassical trade theory, shows that an increase in the relative price of skill-intensive goods would increase the relative wages of skilled workers. The less-common second measure is the relative price of traded goods. To illustrate the potential role of the relative price of traded (to nontraded) goods, we develop and simulate a simple Salter-Swan model with firm-level heterogeneity. Firm-level heterogeneity has become almost a standard for recent trade models, including those that focus on labor-market effects of globalization. [2]

[2] Helpman et al. (2014) is a prominent example a model that employs firm-level heterogeneity to illustrate the effects of trade on inequality. Through simulations, they use data from Brazil to show that trade and inequality follow an inverted U-shaped pattern: inequality rises at first and then falls with the share of exporting firms. In their model, the turning point for inequality emerges when 40% of the firms export.

An important difference between these two mechanisms is that they have different implications for how inequality should behave between and within demographic groups. Most of the papers in this literature focus on changes in inequality that are between demographic groups: skill, education, age, gender, and so on. On the other hand, models with firm-level heterogeneity predict that observationally identical workers can earn different wages and, so, any change in inequality predicted by such models would be *within* demographic groups.[3]

To illustrate the potential of relative price movements in explaining inequality, we study Mexico over the 1990-2014 period. Mexico is one of the most studied Latin American countries because it is both one of the most unequal countries and a liberalization leader, having embarked on ambitious trade liberalization programs over the last twenty years. We first briefly present evidence on changes in the relative price of Mexico's skill-intensive goods. We show that those changes help explain the initial rise in inequality but not the subsequent sustained decline that motivates the Salter-Swan model. The Salter-Swan model generates several predictions that we then evaluate using both census and household labor market data. We show that the data are consistent with the predictions of the model, which implies a potentially very important role for firm-level heterogeneity in explaining changes in wage inequality.

The paper is organized as follows. The next section presents some stylized facts about labor-income inequality in Mexico and motivates the Salter-Swan model with heterogeneous firms. Simulating a calibrated version of the model generates several predictions that we then evaluate using both population census data and household survey data. Section V concludes.

II. Wage Inequality in Mexico: 1990 to 2014

[3] Notably, it is well documented that observable demographic factors (age, education, and gender), occupation, and industry explain far less than half of the individual-level wages. The residual may be due to worker-specific characteristics or firm-specific characteristics (such as match quality). Recent literature focuses on match quality and firm-level heterogeneity as explanations for wage inequality. Prominent examples include Helpman et al. 2014, Dix-Carneiro 2014, and Dix-Carneiro and Kovak 2014. These models illustrate that trade-related changes in inequality are likely due to firm-level heterogeneity. Empirical evidence from Brazil supports predictions from these models.

While this paper is primarily focused on changes in inequality over time, it is important to note that Mexico is characterized by relatively high inequality. Table 1 shows that Mexico is among the top 25 least equal countries. Mexico's pattern of inequality over time offers an excellent opportunity to learn about the link between globalization and inequality. Dozens of papers have tried to explain the initial rise in inequality that occurred after Mexico joined the GATT in 1986. When considering the relationship between globalization and wage inequality, however, it is important to explain both rising and falling inequality. Explaining falling inequality is important because around 1997, Latin American wage inequality generally, and Mexican inequality in particular, started to fall. Figure 1 shows two separate measures of Mexican earnings inequality. The first is based on the nonproduction-production worker wage ratio in manufacturing. The manufacturing wage series is calculated using data from the *Encuesta Industrial Mensual* (Monthly Industrial Survey) available on line at http://dgcnesyp.inegi.gob.mx/bdiesi/bdie.html. The wage series is the average wages of nonproduction workers divided by the average wages of production workers.

The fall in inequality is not limited to manufacturing. The evolution of the Gini coefficient calculated from household surveys for 16-65 year-old males in 20 urban areas exhibits the same pattern. The rise and subsequent fall in inequality was first documented in Mexico following the North American Free Trade Agreement (NAFTA) by Robertson (2004) and followed by Robertson (2007) and Esquivel et al. (2010). Falling inequality was subsequently documented throughout Latin America (Lopez-Calva and Lustig 2010). Note that the manufacturing series rises more quickly but falls more slowly.

Many trade theories, including the neoclassical Heckscher-Ohlin (HO) model and the related Stolper-Samuelson theorem, suggest that it is output prices that drive wage inequality. Stolper and Samuelson (1941) show that an increase in the relative price of, say, labor-intensive goods would increase the demand for labor relative to human capital (e.g. education) in the economy. This increase in demand causes wages to rise and the price of human capital to fall. Figure 2 plots the relative prices of skill-intensive goods in Mexican manufacturing from 1988 to 2005. The ratio of nonproduction to production

worker employment defines skill intensity.[4] Figure 2 shows that the relative price of skill-intensive goods rose after Mexico lowered tariffs upon entering the GATT. Hanson and Harrison (1997) and Robertson (2004) show that the change in relative prices matches the change in tariffs. Prior to liberalization, Mexico had higher tariffs on, and reduced the tariffs more of, less-skill intensive goods, causing the relative price of skill-intensive goods to rise. When NAFTA went into effect, however, the relative price of skilled goods reversed and began to fall. That is, when Mexico liberalized trade with relatively skill-abundant Canada and the United States, the relative price of skill-intensive goods in Mexico fell. To illustrate the break in the relative price series, Figure 2 also plots the relevant additive outlier test statistic for unknown breaks proposed by Vogelsang and Perron (1998). The local extremes of the test statistic indicates a trend break. The global maximum appears in June 1997. Note that after this break the relative price of skilled goods falls but then either levels off or rises slightly through 2004. The rise in the 1987-1997 period is the most dramatic change in the series, which is consistent with the fact that tariff changes were much more dramatic when Mexico joined the GATT than when NAFTA went into effect.

After the price effect of NAFTA, Mexico also faced rising competition from China. The rise of China, as an example of the rise in globalization generally, may very well have affected the relative prices of tradable goods overall such that the relative prices of tradable goods fell relative to nontraded goods over time. Figure 3 shows that, in fact, Mexican consumer prices of tradable goods have steadily fallen (with the brief exception of the peso devaluation in December 1994) over time. The change in the relative price of tradable goods plays a significant role in the "new new" trade models based on Melitz (2003). In these models, workers move from less productive to more productive firms within industries, possibly in response to changes in trade costs. Since wages can vary systematically across heterogeneous firms (due to efficiency

[4] Output prices are calculated as the Fisher Index of unit values. The Fisher index is the geometric mean of the Paasche and Laspeyres price indices. Figure 2's price index is the average price of the top third most nonproduction worker intensive industries divided by the average price of the bottom third nonproduction worker intensive industries. The middle third is omitted. Robertson (2004) presents evidence that shows that for Mexico the nonproduction/production worker ratio is a good proxy for skill intensity.

wages, labor mobility costs, and search frictions) the decline in the relative price of tradable goods may have affected wage inequality within demographic groups (across firms).

When comparing Figures 1, 2, and 3, an intriguing possibility arises. Rising inequality between 1988 and 1997 is consistent with the rise in the relative price of skill-intensive goods, as predicted by the HO model. After June 1997, however, the relative price of skill-intensive goods exhibits a break in trend and essentially levels off, opening up the door for other trade-driven forces to affect inequality and, in particular, inequality that is found "within" demographic groups. Given the relatively large movements in the relative price of traded goods, we now turn to a Salter-Swan model with firm-level heterogeneity to predict the effects of changes in the relative prices of non-traded goods.

III. Salter-Swan Model with Heterogeneous Firms

While the early debate about trade liberalization and inequality was in full gear, Melitz (2003) was sowing the seeds for a deeper understanding of the links between trade and inequality. Melitz (2003) presents a model that is different from the neoclassical models described earlier in that it does not assume that all firms are identical. These differences across firms arise from firm-specific production ability: some firms are simply more productive than others. In the presence of fixed costs for production and additionally for exporting, firms within a given industry will separate into three groups. The first includes the firms that are not productive enough to compete with any other firms, so they simply shut down and do not produce. The second category consists of firms that are productive enough to produce, but not productive enough to export. Exporting requires higher productivity, so that the model predicts that the firms within an exporting industry are the largest and most productive firms in that industry.

The results of this model suggest that inequality may arise from differences across firms for observationally identical workers. If only a fraction of firms export, then rising relative prices of tradeable goods will allow these firms to expand – perhaps at the expense of the less-productive non-exporting firms. If exporting firms pay higher wages, then wage inequality within observationally identical demographic groups (that is, between the exporters and the non-exporters) will increase. Rising tradable goods prices

may also allow firms that were paying lower wages to increase the wages they offer once they start exporting. In this case, rising tradeable goods prices may reduce inequality.

Our theoretical framework combines the Melitz (2003) heterogeneous firms with the Salter-Swan model.[5] The Salter-Swan model has been applied to developing countries in which non-traded (or semi-traded) goods play a significant role in the economy. Thierfelder and Robinson (2003), for example, illustrate how the presence of semi-traded goods can reverse the Stolper-Samuelson predictions. Our goal is to identify how the relationship between the traded and non-traded sector can affect inequality, which makes the Salter-Swan model appropriate. The demand and production structure outlined below are followed by the solution of the model. The solution generates predictions about the relationship between inequality and the relative price of tradeable goods.

A. Demand

Consider an economy with three goods. The first (*a*) is produced by heterogeneous firms and can be exported or sold domestically. The second is a non-traded good (*b*) that is produced domestically by homogeneous firms. The third (*m*) is imported. Consumers consume all but exports, so that utility is a function of the remaining goods. All goods are imperfect substitutes in consumption. Consumers maximize utility subject to their budget constraint, which is a function of the prices of each kind of consumed good.

$$\max U(a,b,m) \text{ s.t. } B(y,p_a,p_b,p_m) \qquad (1)$$

Workers each have one unit of labor that they inelastically supply to the market. The variable y represents the income of a representative worker.

The price of the non-traded good p_b is taken to be numerairre. As in many trade models, the Salter-Swan model assumes that the economy is small, which implies that import and export prices (P_m and P_a) are exogenous and therefore can be represented with a composite traded goods price $P_t = (P_a/P_m)$. This price

[5] Salter (1959) and Swan (1960).

captures movements that are commonly associated with international prices. For example, trade liberalization would increase the price of exported goods and reduce the price of imported goods. Both of these effects are represented by an increase in P_t. This specification allows us to focus on the relative price of tradable and non-tradable goods P (= P_t / P_b), which is sometimes referred to as the real exchange rate (e.g. Devarajan et al. 1993).

Domestic markets clear and the lack of time precludes savings. Therefore, consumers exhaust their income and all domestic production (*b* and *a* that is not exported) is consumed. The demand for imports, therefore, is a residual demand in the sense that remaining income is spent on imports, with the quantity of imports depending on the (exogenous) price of imports.

B. Supply: Productivity, profits, and the firm's decisions

Sector *a* is characterized by heterogeneous firms that are differentiated by a firm-specific productivity parameter *φ*. Following Melitz (2003), firms in sector *a* have the option to enter the market. After entry, firms learn their productivity parameter *φ*. The *ex ante* productivity parameter distribution is described by $g(\overline{\varphi}, \sigma_{\varphi}^2)$ and follows an exponential distribution.[6] The productivity parameter enters in the cost function. To keep the model simple, we begin with the assumption that production is a function of labor, *l*, and can be represented as $Q = \gamma l^{\alpha}$ in which γ represents total factor productivity (TFP) and α captures decreasing marginal productivity of labor. The firm is small and can affect neither the market price *P* (defined as the real exchange rate as described above) nor the wage paid to labor *w*. To produce, firms incur a fixed cost F_d .[7] Ex ante profits are

[6] A common assumption for the productivity parameter is that it follows a Pareto distribution. The Pareto and the exponential distribution are closely related. If X has a Pareto distribution with a minimum of *a* then $y = \log\left(\frac{x}{a}\right)$.

[7] In some models (e.g. Bernard et al. 2007), the fixed cost goes to labor and becomes part of labor demand. We simplify by having fixed costs (both domestic and the exporting fixed cost introduced in the next section) be a pure loss. The main implication of this assumption is that the economy's equilibrium is characterized by a small but

(2) $$\pi = PQ - \frac{wl}{\varphi} - F_d$$

The variables P, φ, w, γ, and α uniquely define the profit-maximizing level of *l*. An increase in the output price, TFP, and the individual-specific productivity parameter increase labor demand at the firm level.

(3) $$l^* = \left(\frac{w}{P\alpha\gamma\varphi} \right)^{\frac{1}{\alpha-1}}$$

Profits must be at least as large as F_d for the firm to stay in the market and produce. The result is a cutoff value for φ that is required for the firm to remain in the market. Firms opting to leave the market truncate the ex post φ distribution and result in higher average productivity levels than in the ex ante distribution of firms.

C. Open economy

To export, firms incur a fixed cost, F_x. Exporting is conditional on producing for the domestic market (that is, the firms have to be viable domestic producers first). If international transportation costs follow the usual "iceberg" assumption, then Qτ goods must be exported for the quantity Q to arrive (τ>1). Under these conditions, firms in sector *a* who export earn a premium. To keep the model simple, we assume that the export price (P_x) is a fixed markup over the domestic sales price. Specifically, $P_x = \tau P$. Foreign tariffs affect the markup in that τ = premium/tariff. An increase in foreign tariffs lowers the premium and high enough foreign tariffs reduce exports to zero. These conditions introduce an indeterminacy because the higher prices in foreign markets can offset the higher fixed costs required for exporting. We restrict our attention to values of τ for which some firms close (and produce nothing), others enter the domestic market (but do not export), and the remaining firms export only. Under these conditions, firms will choose to export if

constant trade surplus that is used to cover the fixed costs. The implications for inequality would not be affected if the fixed costs were evenly distributed among all workers.

(4) $$P_x Q - \frac{wl}{\varphi} - F_d - F_x > PQ - \frac{wl}{\varphi} - F_d > 0$$

The result of the additional fixed cost is that firms that export are more productive and larger than firms that do not export.

D. General Equilibrium

Sector *b* produces exclusively for the domestic market with homogeneous technology. Assume that the second sector is characterized by decreasing returns to scale in the sense that the marginal product of labor is falling. Labor demand in sector *b* can be characterized by

(5) $$l_b = f(\kappa, \lambda, w)$$

in which the parameters κ and λ characterize the labor demand function. In practice we assume that labor demand in sector *b* is linear so that κ and λ represent intercept and slope. The economy is assumed to be characterized by full employment. The assumption of full employment means that total labor supply (L) is perfectly inelastic. Under these conditions, employment in the second sector is equal to the total employment minus employment in the first sector.

(6) $$L = l_a + l_b$$

and

(7) $$l_j = \sum_i l_{ij}$$

in which $j \in (a,b)$ and individual firms are indexed with *i*. Since firms are homogeneous, the aggregate labor demand can be represented by a single labor demand function and all workers receive the same labor income. Given small heterogeneous firms in the first sector, small homogenous firms in the second sector, and perfect mobility between plants and sectors, wages are determined in the aggregate labor market and equalize across sectors.

In a model with only one factor, profits go to the workers. We therefore distinguish income from wages. In the homogeneous sector, the assumption of falling marginal product implies that the wage bill (w*L) is less than the value of production. We allow workers to receive an equal share of the additional value generated in the homogeneous sector, such that income, *y,* is equal to the integral of the marginal revenue product from zero to total employment in sector *b* divided by total employment in sector *b.*

$$y_b = \frac{\int_0^{l^*} mrp_{bi}}{l_b^*} \tag{8}$$

This integral is equal to the wage bill plus the sum of the remainder of the generated value divided by the total employment in sector *b.*

Since we model sector *b* as the residual sector that effectively determines the reservation wage, perfect mobility between sectors implies that income in the residual sector (rather than wages) becomes the minimum income in the heterogeneous sector. That is, workers will either work in the homogeneous sector for income y_b or in the heterogeneous sector for at least y_b. Workers in the heterogeneous sector queue for jobs in the sense that sector *a* can hire as many workers as they want as long as they offer at least the reservation wage. Income for workers in the heterogeneous sector is then $y_{ai} = y_b + \frac{\pi_i}{l_i}$, which is the income they could earn in the homogenous sector plus an equal share of the firm-specific profits. Employment decisions at the firm level in the heterogeneous sector are based on y_b because profits are realized ex-post. The resulting labor demand therefore has a general equilibrium effect on y_b.

In this open economy model, the markup, the foreign price, and the domestic prices are all related. Figure 4 offers one way to conceptualize the model. Figure 4 may look familiar to anyone familiar with standard trade theory, but one key difference is that, although the figure would imply that sector *b* is a perfect substitute for imports, in the model they are imperfect substitutes for consumers. They are, however, both alternatives to consumption of sector *a* production. The other key difference with the

standard figure is that the domestic consumption (production) of *a* is produced by different (less productive) firms than those exporting *a*.

In Figure 4, both sectors *a* and *b* are characterized by decreasing marginal product of labor (increasing production costs). The relative price of tradable goods is represented by the slope of the price line labeled *P*. The relative price determines the cutoff between domestic production and exports in sector *a* and the assumption of full employment then determines the employment, and therefore production, in sector *b*. Total income equals the sum of the total value of production in sector *a* and domestic production of *b*. Income left over after paying for domestic production goes towards imports.

Figure 4 can help illustrate the effects of a change that either increases the price of exports or reduces the price of imports (from, for example, reducing import tariffs). Both would be represented by the *P* line becoming steeper (as shown as the dashed lines change to the solid lines). An increase in the real exchange rate will cause exports to increase. Domestic price changes also affect the allocation between sectors *a* and *b*. Specifically, a falling real exchange rate will cause workers to migrate out of the heterogeneous sector and into the homogenous sector.

What is different in the heterogeneous case is that an increase or decrease in the mark-up (e.g. through a change in foreign tariffs) that does not affect the home price of sector *a* will affect income but not wages because the markup contributes to profits but wages are disciplined by the domestic labor market, which, in turn, is driven by the real exchange rate. In this model, the change in the mark-up only affects the cut-off for exporting.

Table 2 contains the list of exogenous and endogenous variables in the model. The variable *P* represents the real exchange rate, which drives the results of the model. The alpha and total factor productivity are parameters of the production function. Labor demand in sector *b* is characterized by a slope and intercept that are also specified as exogenous variables. The reservation wage is both exogenous to individual firms but endogenous to aggregate labor demand in both sectors *a* and *b*. Firms in sector *a* use the reservation earnings (the earnings in sector *b* to determine firm-level employment (it acts as the wage

for sector *a*). It is affected by aggregate labor demand because it has to respond to the employment in sector *b*, making it endogenous.

In practice, the model is solved by first changing the real exchange rate *P*. The change determines the level of employment in both sectors, which generates a feedback effect on the reservation wage. The reservation wage equilibrates between the two sectors in a way that generates an equilibrium level of employment in both sectors given the real exchange rate.

Once employment in each sector is determined, the rest of the endogenous variables are determined. The full list of model's endogenous variables is found in the right-hand-side of Table 2. We generate predictions for the three variables that seem to be the most relevant for inequality. The first is the variance of wages in *a*. The variance of wages in *a* arises because the change in the real exchange rate results in a new equilibrium cutoff between exporters and nonexporters in sector *a*, and different levels of firm-level profits among both exporters and nonexporters in sector *a*. The second is the wage ratio between sectors *a* and *b*. The third is the share of workers in the tradable sector as a function of the relative price of traded goods.

Model Simulation

The model simulation takes place in two main steps. The first is to identify parameter values and describe the initial equilibrium. Given the number of parameters, there are parameter values that could generate four general outcomes: no firms produce anything, firms produce only for the domestic market, firms produce only for the export market, and a mixed solution in which some firms choose not to produce, some produce for the domestic market, and some produce for export. To begin we select initial parameter values such that the initial equilibrium falls into the last (mixed) category.

Figure 5a illustrates a typical mixed equilibrium for sector *a*. The initial model parameter values are also shown in Figure 5a. The parameter values for the labor demand curve in sector *b* are chosen so that the demand curve is relatively elastic, reflecting the "residual sector" nature of sector *b*. Changing parameter values affect the values of the endogenous variables, but have little effect on the qualitative path

of our variables of interest (e.g. inequality) unless the changes in the real exchange rate drive the model into one of the corner solutions described above (e.g. generate a result in which no firms produce). The starting values of the parameters are chosen to avoid corner solutions for the observed range of real exchange rate values.

The x-axis contains the (exponentially-distributed) phi values. Profits are measured along the vertical axis. Some firms (with low phi values) have profits that are insufficient to cover their fixed costs and they produce zero. Firms that can cover their fixed costs produce positive amounts and fall into two groups. The first group (in the middle of Figure 5a) have higher profits in the domestic market, and therefore produce only for the domestic market. The remaining firms (with high phi values) produce only for the export market.

The second step is to simulate the model using Mexican data. The driving variable is the real exchange rate, defined earlier as the usual Salter-Swan variable of the price of tradable goods relative to the price of non-traded goods. Figure 5b shows the effect on the equilibrium of an increase in the real exchange rate. To calibrate the real exchange rate values, we use Mexico's price data. Mexico's INEGI posts monthly consumer price data on-line. The consumer price index data are disaggregated into eight categories. We classify these eight into "tradeable" and "nontradeable" groups. The tradable industries include food, clothing, and furniture. The nontradeable industries include housing, health, transport, education, and other services. We then take the unweighted arithmetic average of these indices for each group. Figure 6 depicts the movements of the two price series over time.

To simulate the effects of the changes in the real exchange rate in the simple heterogeneous-firms Salter-Swan model, we normalize the real exchange rate value in the first period (January 1988) to match the variable P in the model. Subsequent changes in the real exchange rate are then applied to the model, which is then solved for new equilibrium values of the endogenous variables shown in Table 2.

Of the list of endogenous variables listed in Table 2, we are particularly interested in comparing the predictions for the "within" inequality. Since all workers are identical, we define within inequality in the same conceptual way that it is defined earlier in the paper: the dispersion of earnings that remains after the

effects of observable characteristics (especially age, education, gender, and industry) have been removed. Since all workers are assumed to be identical in the model, the observed inequality that is predicted by the model is comparable to the inequality that remains after controlling for the effects of observable characteristics. Between industry differences (in particular) explain very little of overall inequality. In our model, we therefore focus on the within inequality that may arise from firm heterogeneity. To measure inequality, we use the variance of earnings across firms using the usual calculation of variance.

The dashed line in Figure 7 represents the time series of within-sector inequality that results from plugging the observed Mexican real exchange rate into the model and solving period-by-period. Not surprisingly, the pattern of within-sector inequality follows the path of the real exchange rate: falling for much of the sample with the exception of the appreciation that occurred in the immediate aftermath of the peso crisis (during the first quarter of 1995).

The model predicts that the real exchange rate movements would be associated with falling inequality throughout the sample. Figure 7 also includes the standard deviation of the residuals of the quarter-by-quarter Mincerian wage equations. The standard deviation of the residuals rises during the pre-NAFTA period but falls during the post-NAFTA period. The fall in standard deviation of the residuals is consistent with the predictions of the model for the post-NAFTA period, but does not match for the GATT period (1987-1994) when the relative price of skill-intensive goods, and the demand for skills, were rising. The predicted inequality does not match the rise in inequality during the pre-NAFTA period, but it does match the fall in inequality after NAFTA. The correlation between the two series prior to 1998 is -0.83 and the correlation between the two series after 1997 is 0.82.

One possible explanation for the mismatch of the two series in the 1988-1997 period but a match during the 1997-2011 period is that 1988-1997 was characterized by a sharp increase in the relative price of skill-intensive goods. The increase in the relative price of skill-intensive goods could have swamped the otherwise equalizing effect of the falling real exchange rate. This explanation is supported by two other findings. First, when the relative prices of skill intensive goods level stop rising and level off, wage inequality follows the predicted path from the real exchange rate. Second, the HO model predicts a rise in

between-group inequality, while the Salter-Swan model with heterogeneous firms predicts a fall in within-group inequality. We formally evaluate this prediction in the next section.

The simulation exercise also generates other interesting results. Figure 8, for example, shows the predicted and actual share of employment in the traded sector. The share of employment in *a* is predicted to fall as the relative price of tradables falls. Figure 8 shows that the model over-predicts the actual shift between sectors, but it is worth pointing out that the model has no adjustment costs. Estimates of the cost to workers from moving between sectors are very high (Kaplan, Lederman, and Robertson 2013), and therefore it is not surprising that the actual shifts are smaller.

Finally, the "between industry" inequality is measured by the ratio of average wages of sector *a* to average wages in sector *b*. There is a slight increase in the prediction of between-industry inequality during the GATT period, and a much larger increase after 2000. Note that the overall change in between industry inequality is less than 2% over the entire sample, which is a result that can be compared using Mexican data.

The structural model relies on the assumption that workers are homogenous and that changes in labor-income inequality is driven by inequality within the sector with heterogeneous firms. Although the model is tractable, it is worth assessing if these features of the model are broadly consistent with Mexican labor market data. We now compare the model's predictions to Mexican labor force data.

IV. Variance Decomposition 1990-2010 Census Data

We begin by using data from the Mexican Population Census. We employ the 10% samples from the 1990, 2000, and 2010 Mexican censuses (Minnesota Population Center 2014). Our main variable of interest is the hourly wage, which is computed by dividing monthly earnings by reported hours worked during a typical week times 4.33. All earnings measures are converted into 1990 US dollars. First, we converted Mexican wages into dollars by using the nominal exchange rate from the Banco de Mexico. We then deflated the wages to 1990 dollars using the US Consumer Price Index (CPI) obtained from the Bureau

of Labor Statistics. We restrict the sample to all men ages 19 to 63. Next, as in Chiquiar and Hanson (2005), we only use Mexican wages that are between US$0.05 and US$20.00.

We use two samples from the Mexican census. The first is a sample of all workers meeting the above criteria. The second is a sample of primarily urban dwellers that includes Mexico City, the State of Mexico, San Luis Potosí, Leon, Guadalajara, Chihuahua, Monterrey, Tampico, Torreon, Durango, Puebla, Tlaxcala, Veracruz, Merida, Orizaba, Guanajuato, Tijuana, Ciudad Juarez, Matamoros, and Nuevo Laredo. We call this the urban sample.

In Table 3, we report the summary statistics from our data for both the rural/urban and the urban sample from Mexico. The table shows that mean wages in Mexico have been stable from 1990-2010. For the whole sample, we see that wages increased modestly from $1.42 in 1990 to $1.55 in 2000 to $1.59 in 2010. Wages in the urban sub-sample are slightly higher but do not exhibit the same monotonic increase from 1990-2010. There have also been significant gains in educational attainment over this period. For example in the whole sample, in 1990, 32.64% of the sample had between 0 and 5 years of education, whereas in 2010, this number dropped to 13.50%. In the urban subsample, the corresponding numbers are 20.85% in 1990 and 8.41% in 2010.

Variance Decomposition

To explore the predictions of the model about the relative importance of "between" and "within" inequality, we begin with a standard variance decomposition exercise that is common in the inequality literature (e.g. Lemieux 2010) in which we break the total variance of log wages in a given country into its "within" and "between" components. The variance at time t can be decomposed into its "within" and "between" components as follows:

(1) $$V_t = W_t + B_t$$

where

(2) $$W_t = \sum_g \theta_{gt} v_{gt}$$

and

(3) $$B_t = \sum_{g,k} \theta_{gt} (y_{gt} - y_t)^2$$

where θ_{gt} is the population weight for cell g at time t, v_{gt} is the variance in cell g at time t, y_{gt} is the average log wage in cell g at time t and y_t is the average of the log wage at time t. The within component measures variation in wages within a group, whereas the between component measures variation across groups. We use two definitions for group g. The first is an age/education group and the second is an age/education/industry group. The results are reported in Table 4.

Three main results emerge from Table 4. The first is rising inequality between 1990 and 2000 and falling inequality between 2000 and 2010. The second main result is that most of the inequality in Mexico (in every period and sample) is within, rather than between age/education groups. For example, the within component makes up over 81% of total inequality for the whole sample in 1990 (0.646/0.791=81.7%). The third is that differences between industries contribute little to overall inequality. The differences between the top three rows and the bottom three rows is smaller than the differences in the between and within components of inequality.

Wage densities in Panel A of Figure 9 show falling inequality: the 2010 distribution of log wages is more compressed than the distributions of earlier years. The log-wage residuals from a Mincerian wage equation follow a similar pattern of falling inequality over time. Panel B of Figure 9 shows a compression of the residuals in 2010 relative to earlier years.

In Panel A of Figure 10 the changes in the distributions over time show that the frequency of values close to zero increased, which is consistent with the fall in inequality. This pattern is clearer with the residual plots in Panel B of Figure 10. Values farther from zero became less frequent and values closer to zero became much more prevalent.

Household Surveys

We also analyze wage inequality using quarterly household survey data. Mexican household data are from the Encuesta Nacional de Empleo Urbanao (ENEU) and the Encuesta Nacional de Empleo (ENE) over the period 1988-2004 and from the Encuesta Nacional de Ocupacion y Empleo (ENOE) over the period 2005-2011. Working-age adults who have zero or unreported earnings are excluded, and we further restrict the sample to adult males between 18 and 65 years of age. The Mexican data report monthly earnings; we base our analysis on monthly earnings throughout the paper. The ENEU/ENE/ENOE surveys expanded to cover more rural areas over the last two decades. To maintain a constant sample, we restrict the sample to workers from major metropolitan areas that have consistently been included (the same group that comprise the urban sample for the census data described earlier): Mexico City, the State of Mexico, San Luis Potosí, Leon, Guadalajara, Chihuahua, Monterrey, Tampico, Torreon, Durango, Puebla, Tlaxcala, Veracruz, Merida, Orizaba, Guanajuato, Tijuana, Ciudad Juarez, Matamoros, and Nuevo Laredo.

To compare the relative importance of between and within inequality in the household surveys, we estimated standard Mincerian log-wage equations with education, age, age squared, city, and industry on the right hand side and capture the coefficients of the observed variables, the R^2, and the residuals. The captured coefficients tell us how returns to observable characteristics change over time (e.g. the returns to education as a proxy for the demand for skills). The R^2 and wage residuals indicate the importance of within-industry heterogeneity holding observable worker characteristics constant.

Figure 11 shows the R^2 values for the quarterly Mincerian wage equations. The R^2 rises from 1988 until around 1997 and then falls, which indicates that the change in the wage structure in the 1988-1997 period is increasingly explained by observable characteristics, such as the returns to skill. Indeed, the coefficient on education follows the same path as the R^2 values. After 1997, however, the observable characteristics explain less and less of the changes in wages. The fall in the R^2 values is consistent with the idea that within-industry heterogeneity (holding observable characteristics constant) is increasingly important.

The main lessons from the decomposition of wage inequality are that wage inequality fell between 2000 and 2010 and much of the decline (perhaps as much as half) is due to factors other than returns to age,

education, industry, or other observable characteristics. Firm-specific match quality that arises from heterogeneous firms is one possible source of the inequality that is not explained by observed workers characteristics in the census or household survey data.

V. Conclusions

Wage inequality in Mexico remains high, but it has been falling since the mid-1990s. The neoclassical models (Heckscher-Ohlin and Stolper-Samuelson theorem) focus on the relative price of skill-intensive goods, which rose in Mexico after Mexico joined the GATT but reversed direction after NAFTA went into effect. Inequality follows a similar path. The neoclassical models, however, fail to explain the residual inequality that remains after industry and demographic characteristics (e.g. age and education) are considered. In other words, while falling inequality is consistent with the predictions of neoclassical trade models, recent research has suggested that the neoclassical models that assume homogenous firms miss much of the story.

This paper contributes to this literature in three ways. We first develop a simple model of within-sector heterogeneity to generate predictions of the changes in inequality that might be due to changes in the relative price of tradeable goods. We add firm-level heterogeneity to a simple Salter-Swan model and simulate the changes in within-sector inequality that could emerge even among homogeneous workers.

Our second contribution is to combine micro-data from the Mexican population census and household surveys to evaluate the importance of inequality that is not due to observable characteristics. Consistent with the literature, we find strong and consistent evidence that suggests that age, gender, education, and industry explain a small fraction of total inequality.

Our third contribution is to compare the predicted changes in inequality with actual changes in inequality in Mexico using household survey data. We find that the fall in inequality that occurs since NAFTA is strongly consistent with our model’s predictions of falling inequality that are driving by falling relative prices of tradable goods.

The predictions from the heterogeneous-firms Salter Swan model are not consistent with the rise in inequality that occurred during the GATT period (1988-1994). We echo the possibility that the increase in inequality during that period was due to the sharp increase in the relative price of skill-intensive goods that followed Mexico's tariff reduction upon joining the GATT, which reduced tariffs more for less-skill-intensive goods (Hanson and Harrison 1997 and Robertson 2004). The relative price of skill-intensive goods stops rising around the time NAFTA was implemented and either levels off or falls slightly, perhaps allowing the effect of the falling price of tradable goods to reduce inequality as predicted by our heterogeneous-firms Salter-Swan model.

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Table 1: Gini Coefficients

Country	Gini
South Africa	66.7
Seychelles	65.8
Namibia	59.7
Central African Re	56.2
Colombia	*56.0*
Zambia	56.0
Guatemala	*55.9*
Honduras	*55.3*
Brazil	*53.6*
Paraguay	*53.1*
Panama	*52.7*
Chile	*51.7*
Rwanda	51.7
Swaziland	51.5
Ecuador	*49.7*
Costa Rica	*49.5*
Mexico	***49.4***
Bolivia	*49.2*
Dominican Rep	*49.1*
Angola	49.0
China	48.5
Peru	*47.9*
Nicaragua	*47.7*
Barbados	*47.0*
United States	46.9

Source: Author's calculation using data from Milanovic (2014) All the GINIs dataset. Gini values are the mean over the years 2006-2012 that are available in the dataset. This table includes the top 25 most unequal countries in the data according to the 2006-2012 average. Latin American countries are in italics.

Table 2: Exogenous and Endogenous Variables

Inputs	Outputs
$P_r = (P_t/P_b)$	Total Labor in A
Reservation Income (y_b)	Total Labor in B
Prod. Function Param. (α)	Mean Size Domestic Producer in A
TFP (γ)	Mean Size Exporter in A
Fixed Cost Domestic (F_d)	Total Domestic Emp in A
Fixed Cost Foreign (F_x)	Total Export Emp in A
Total Labor (L)	Avg Income Dom A
LD slope in B (κ)	Avg Income Exp A
LD intercept in B (λ)	Share in A
Export markup (τ)	Share of Export of A
	Number Exporters
	Wage in Sector B
	Profit Sharing in Sector B
	Total Income per worker in B (y_b)
	Average output/L
	Income Ratio Exp/Dom in A
	Income Ratio A/B
	Variance Income in A
	Total Production Value A Domestic
	Total Production Value A Exports
	Total Production Value B
	Total Earnings
	Total Imports
	Overall Mean Income
	Sector A Mean Income

Notes: The reservation income appears in both the inputs and outputs because it is used to determine employment at the firm level in industry *a* and then the resulting labor demand is aggregated across all firms in both sectors *a* and *b* . The model is then solved for the value of y_b that equalizes aggregate labor demand in both sectors. P_r is constructed as the price index of tradable goods divided by the price index of nontraded goods.

Table 3: Descriptive Statistics, Mexican Census

	1990	2000	2010
		Whole Sample	
Hourly Wage	1.42	1.55	1.59
	(1.79)	(1.92)	(1.81)
Age	34.78	35.38	37.10
	(11.20)	(11.04)	(11.38)
Education			
0-5	32.64%	20.39%	13.50%
6-8	26.94%	24.21%	19.99%
9-11	21.77%	26.27%	30.91%
12-15	8.63%	15.43%	20.32%
>15	10.02%	13.71%	15.29%
N	1,263,955	1,597,037	1,754,953
		Urban Sample	
Hourly Wage	1.60	1.77	1.74
	(1.94)	(2.15)	(1.97)
Age	34.58	35.42	37.46
	(10.97)	(10.91)	(11.35)
Education			
0-5	20.85%	12.55%	8.41%
6-8	28.57%	23.06%	17.74%
9-11	26.24%	30.20%	32.90%
12-15	10.95%	18.17%	23.17%
> 15	13.40%	16.01%	17.78%
N	506,669	508,316	360,515

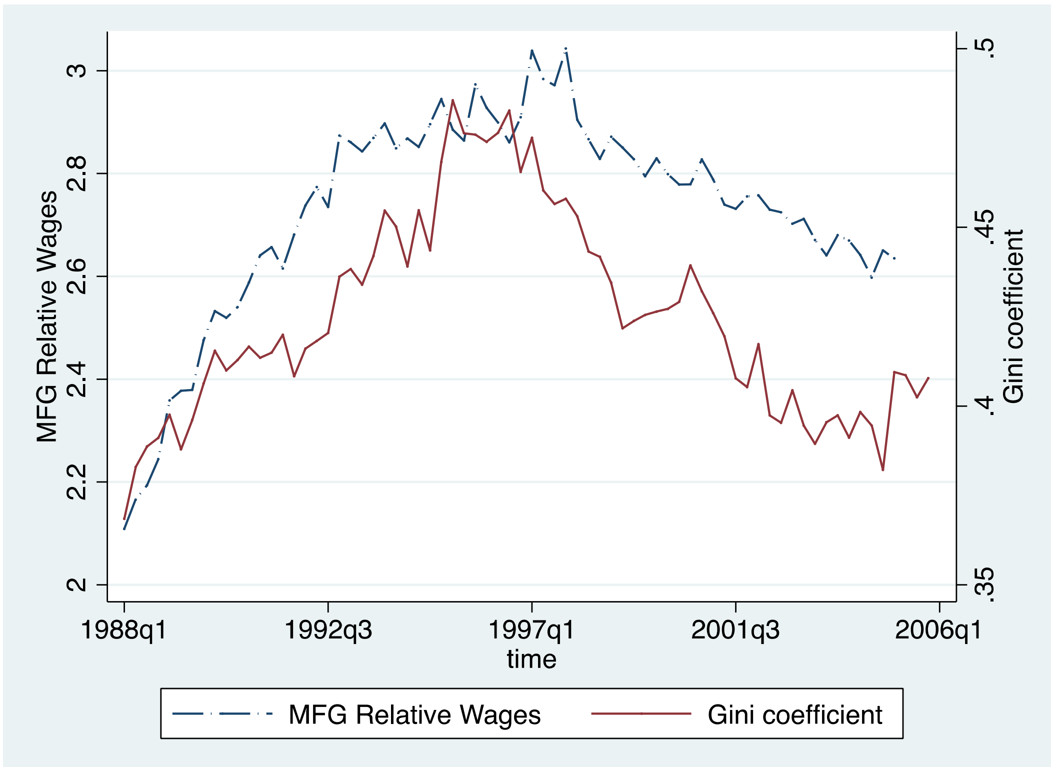
All wages are in 1990 US dollars. The hourly wage was computed by converting wages to US dollars using the exchange rate for that year and then deflating the wages using the US CPI.

Table 4: Variance Decompositions, Census Data

	1990		2000		2010	
	Whole	Urban	Whole	Urban	Whole	Urban
<u>Group</u>						
Age/Education						
Between	0.145	0.144	0.193	0.209	0.149	0.154
Within	0.646	0.583	0.517	0.476	0.457	0.457
Total	0.791	0.727	0.710	0.685	0.606	0.611
<u>Group</u>						
Age/Education/Industry						
Between	0.186	0.161	0.232	0.224	0.171	0.173
Within	0.605	0.563	0.477	0.459	0.434	0.438
Total	0.791	0.724	0.709	0.683	0.605	0.611

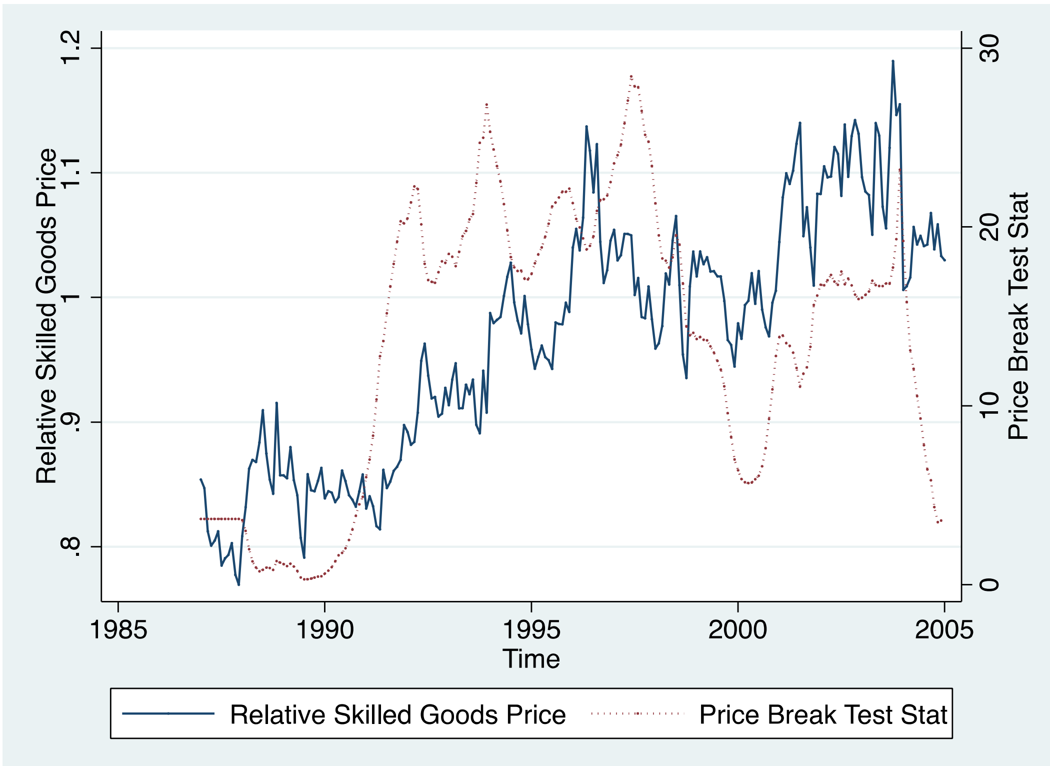
This table reports variance decompositions of log wages into "between" and "within" components from the Mexican Census.

Figure 1: Mexican Earnings Inequality



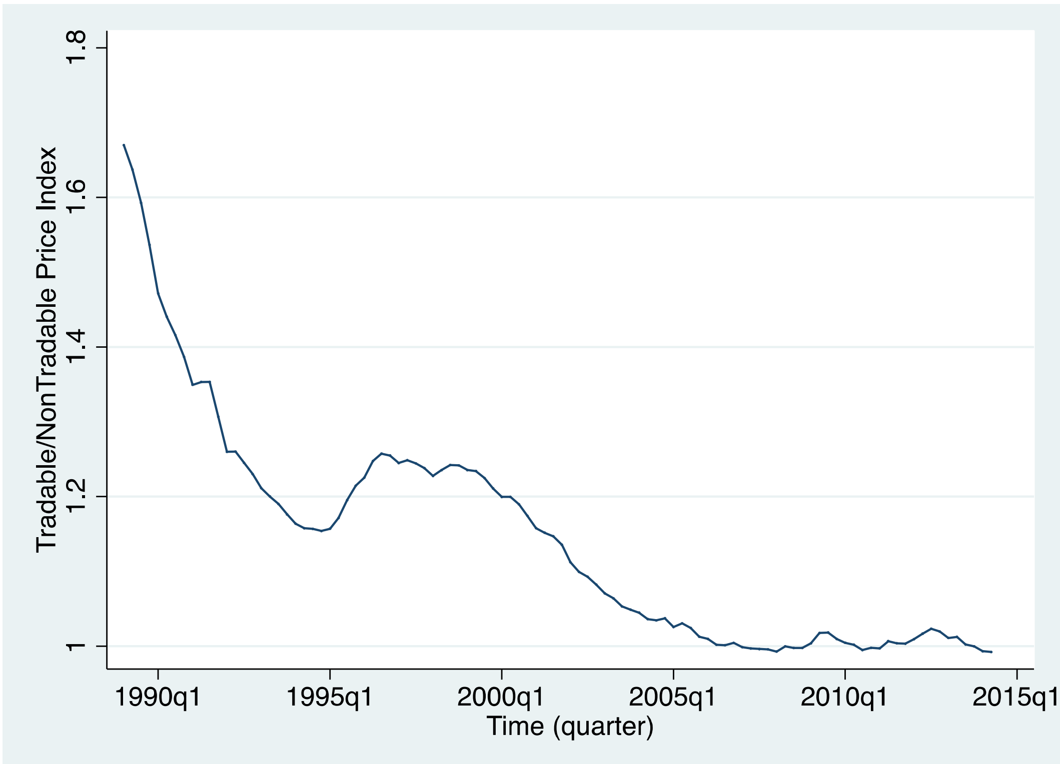
Notes: The MFG Relative wage series is calculated using data from the *Encuesta Industrial Mensual* (Monthly Industrial Survey) available on line at http://dgcnesyp.inegi.gob.mx/bdiesi/bdie.html. The wage series is the average wages of nonproduction workers divided by the average wages of production workers. The Gini coefficient is calculated using monthly earnings of Mexican males ages 16-65 in 20 urban areas in Mexican household surveys (ENEU-ENE-ENOE). The urban areas are Mexico City, the State of Mexico, San Luis Potosí, Leon, Guadalajara, Chihuahua, Monterrey, Tampico, Torreon, Durango, Puebla, Tlaxcala, Veracruz, Merida, Orizaba, Guanajuato, Tijuana, Ciudad Juarez, Matamoros, and Nuevo Laredo. The fact that the samples are not directly comparable is deliberate: although the samples are unique, they generate qualitatively similar patterns in the change in wage inequality.

Figure 2: Relative Price of Skill-Intensive Goods



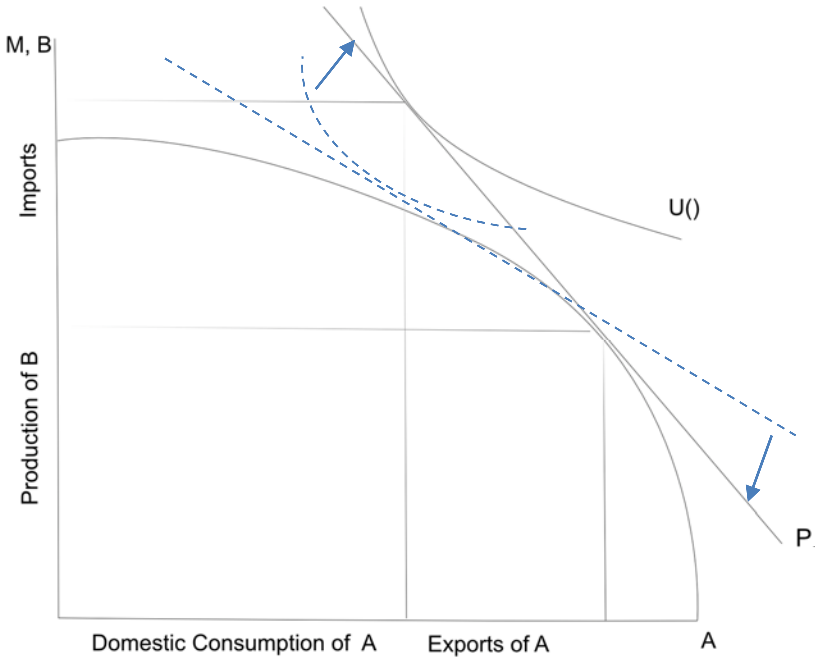
Notes: Based on data from Mexico's *Encuesta Industrial Annual*. The series is constructed by taking the ratio of the Fisher output price (unit value) index for skill-intensive goods (measured as the industries in the top third of non-production to production worker ratio in manufacturing) to less-skill-intensive industries (measured as the industries in the bottom third of non-production to production worker ratio). The broken line plots the relevant additive outlier test statistic from Vogelsang and Perron (1998). The local extremes of the test statistic indicates a trend break. The maximum appears at June 1997. Note the relative price falls until around 2001, when China enters the WTO.

Figure 3: Relative Price of Tradable Goods



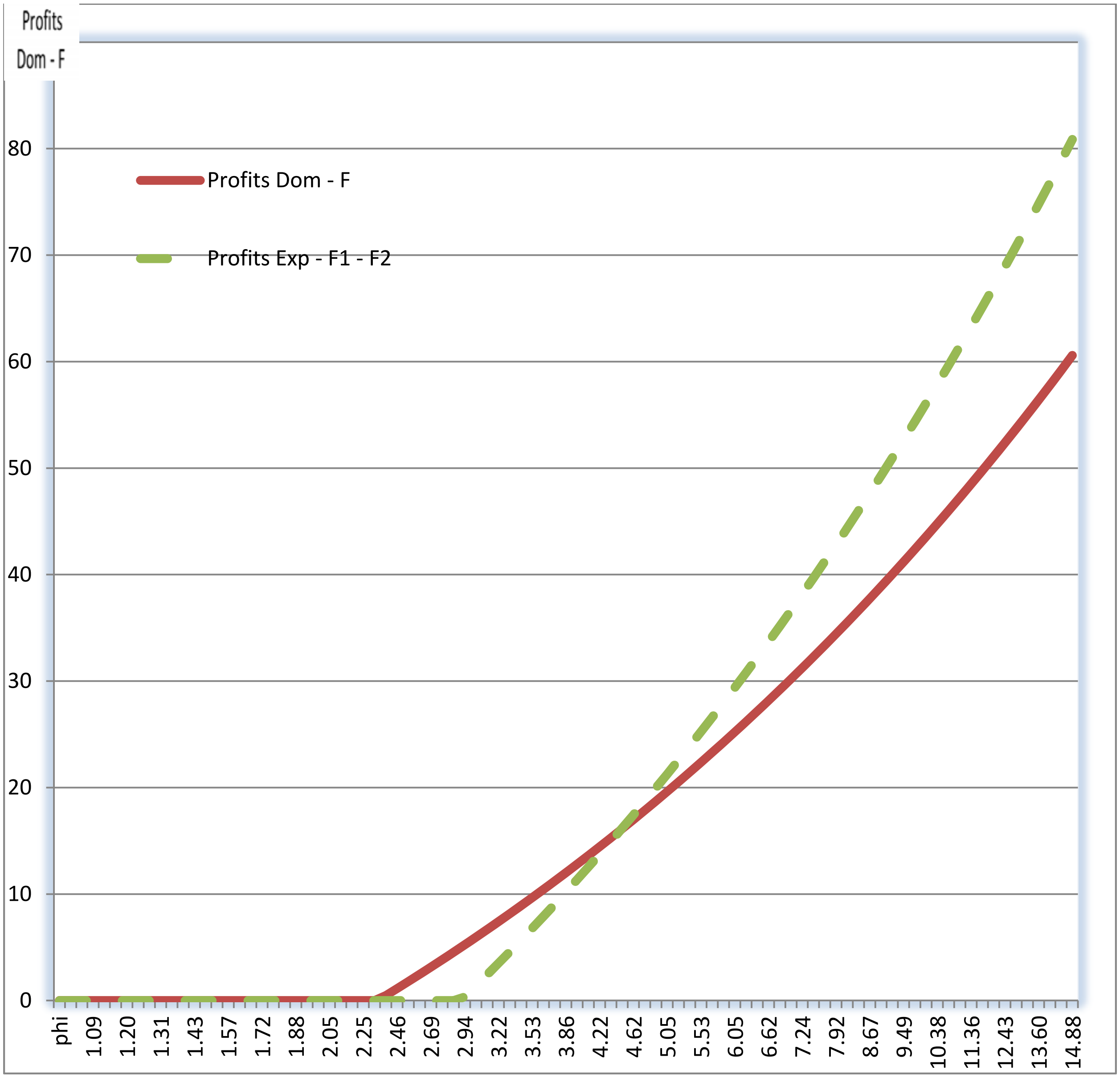
Notes: Consumer price indices using data from INEGI. INEGI reports price indices separately for food, clothes, furniture, housing, health, transportation, education, and other services. We group the first three into the tradable sector and the remainder into the nontradable sector and take the arethemetic average across categories to calculate the relative price of tradeable goods.

Figure 4: 2-dimension Representation of Production and Consumption



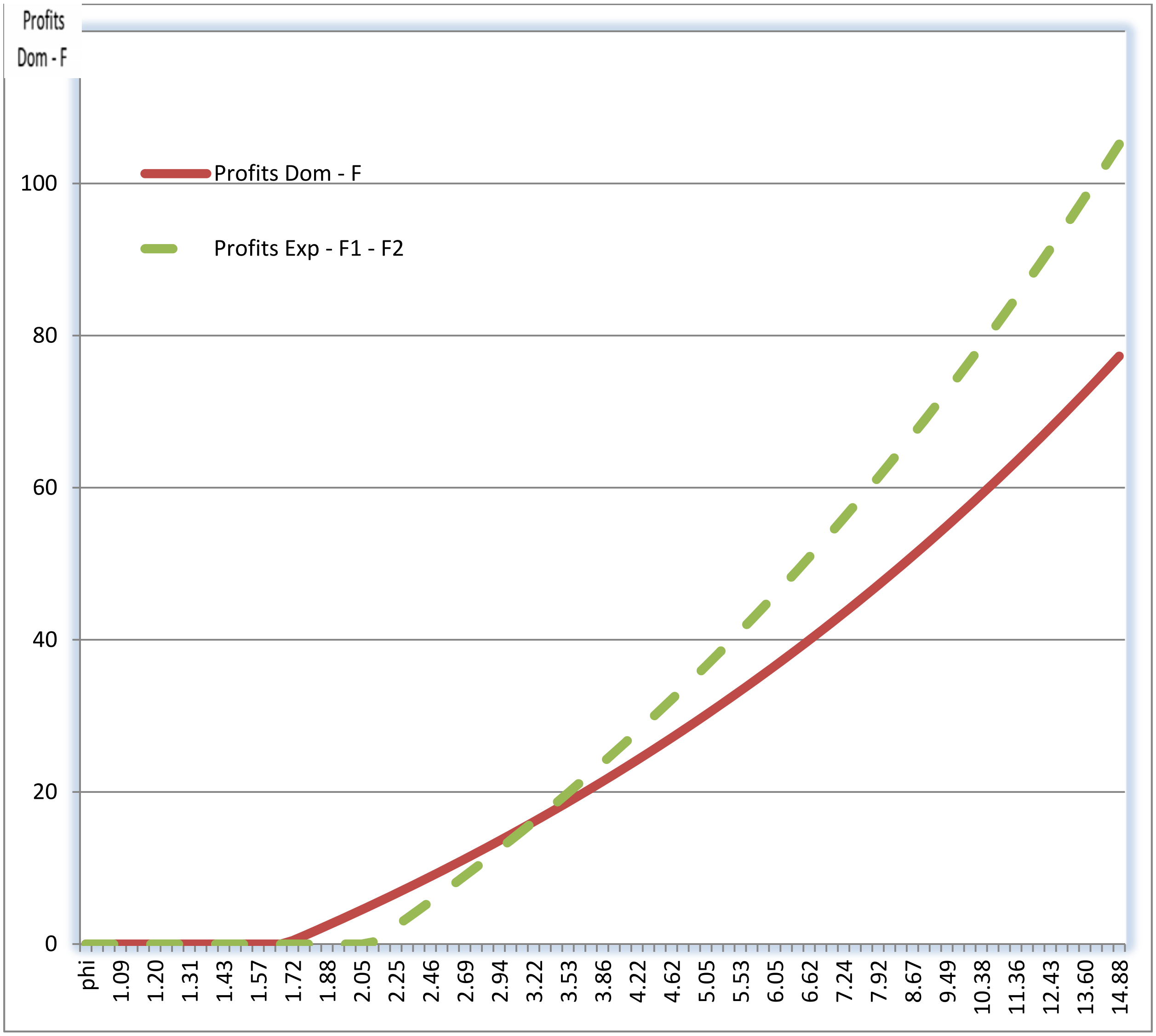
Notes: In this 2-dimensional representation, sector *b* represents non-traded goods that are taken to be substitutes for sector *a* production in consumer demand. This figure implies that imports and non-traded goods are close substitutes for consumers.

Figure 5a: Initial Model Equilibrium



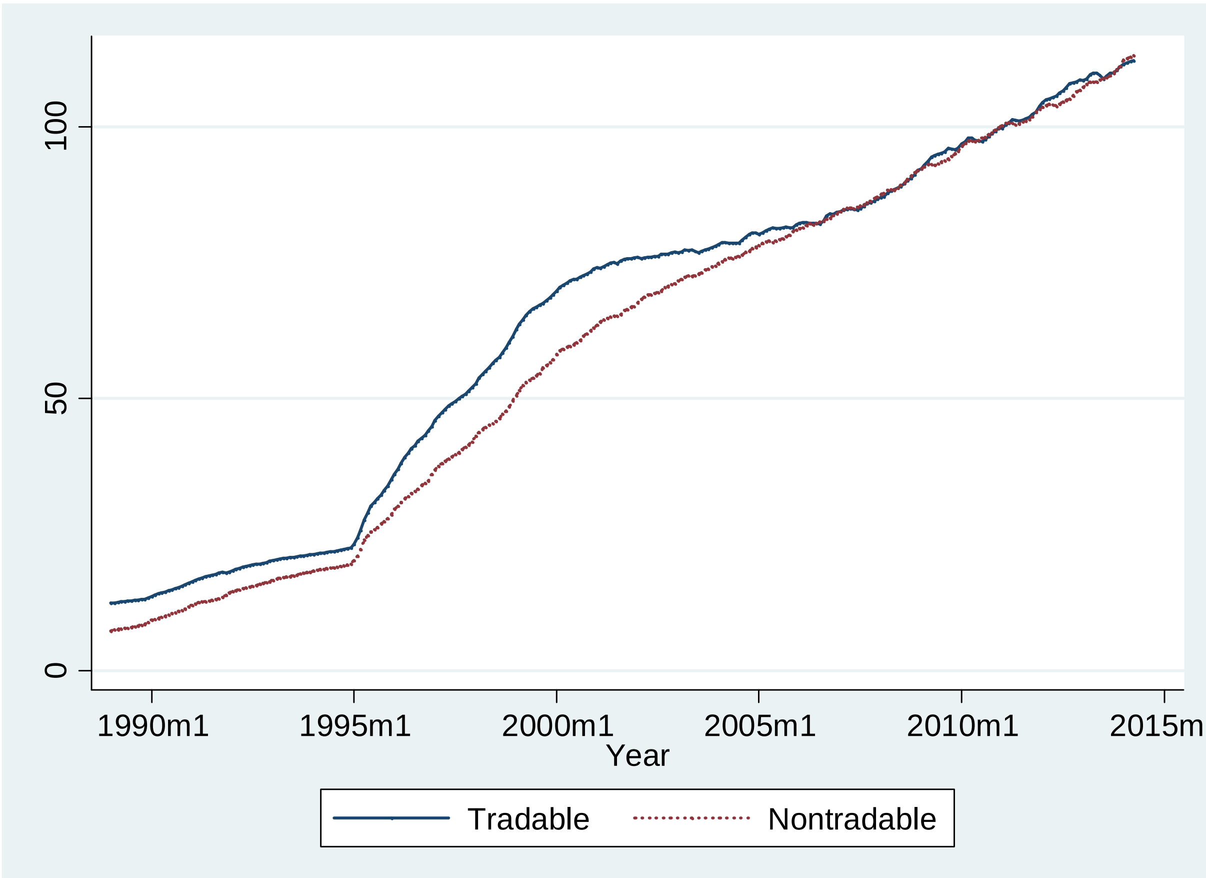
Notes: Values along the x-axis represent the (exponentially-distributed) firm-specific technology phi parameter. The solid line represents the profits from producing in the domestic market. The dashed line represents profits from producing for export. Firms that have zero profits are those whose technology parameters result in profits that are insufficient to cover the fixed cost of producing. The initial values include: P=9, Reservation income in *b* = 5.25, Alpha = 0.3, TFP = 4, Export markup = 1.3, Fixed domestic production cost = 50, Fixed export cost = 30, Total labor =6000, Labor demand slope in *b* = 0.51, and the intercept of labor demand in sector *b* = 6. Figure B below shows the result with P=10.

Figure 5b: Effect of Price Increase



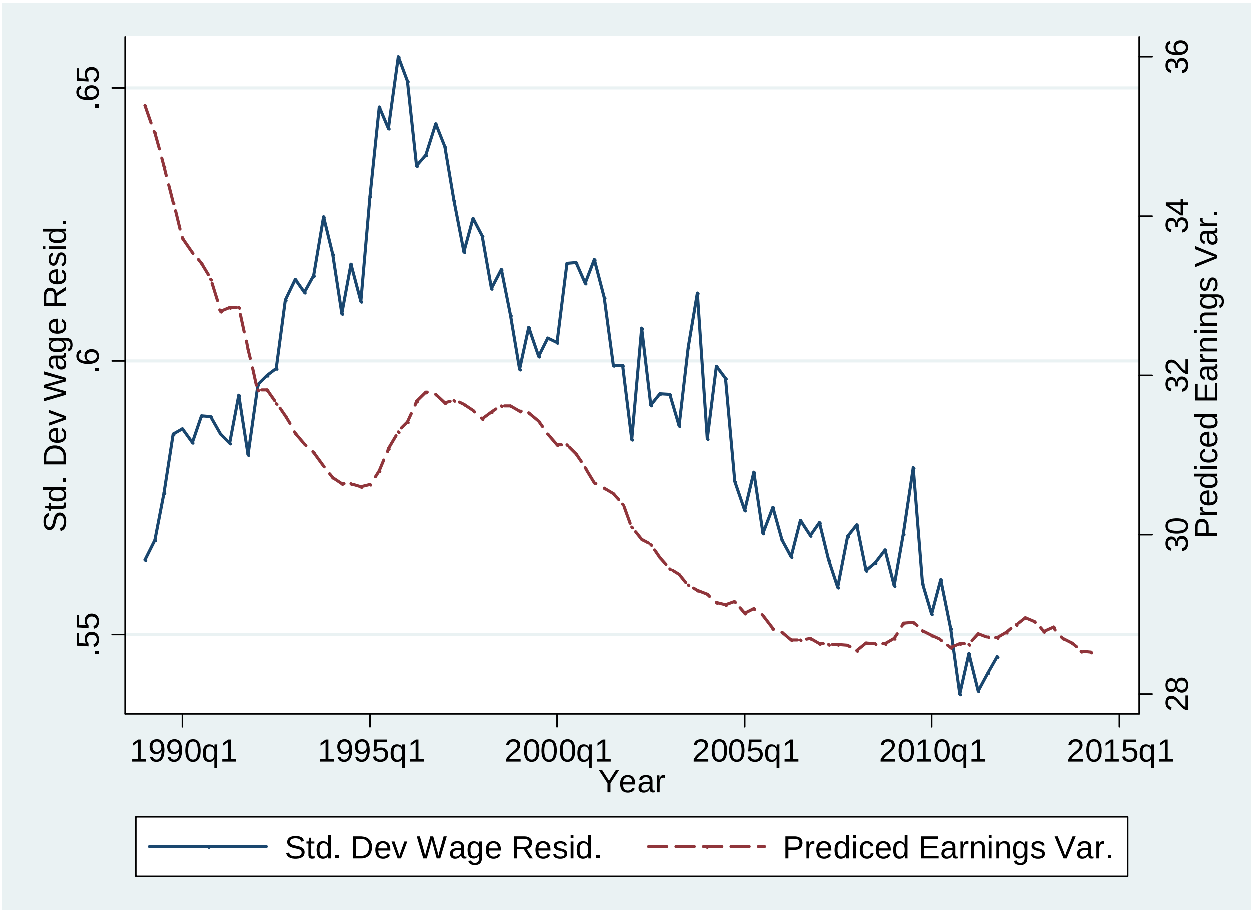
Notes: See notes to figure 5a.

Figure 6: Consumer Price Indices



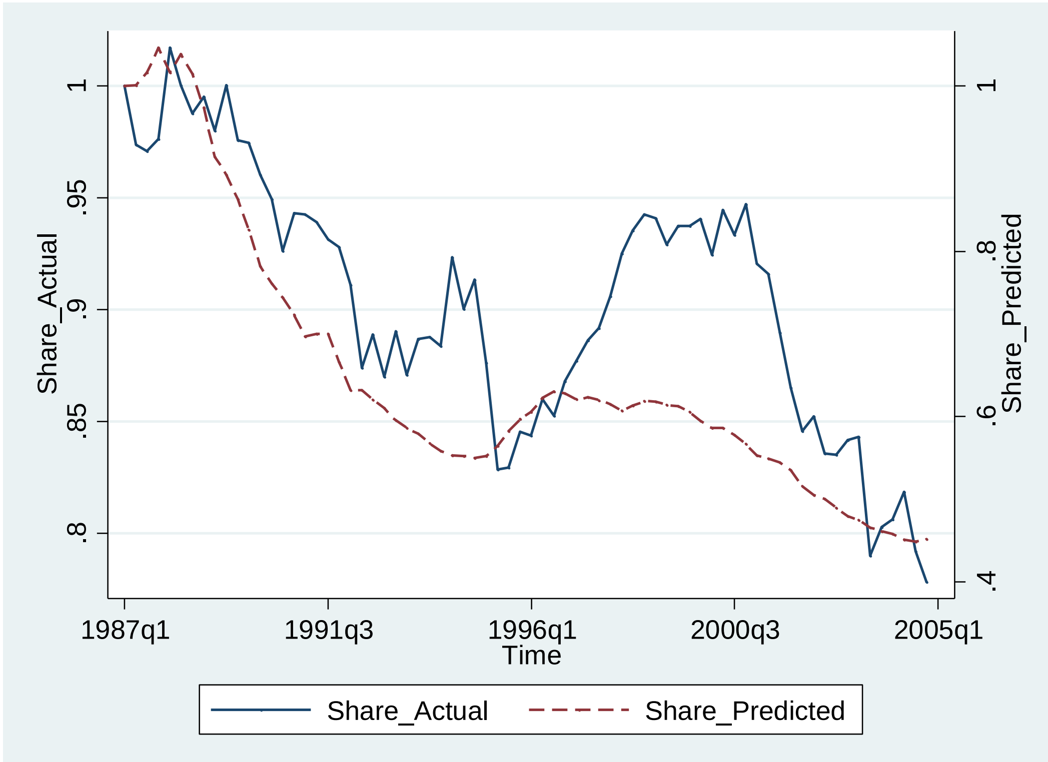
Notes: Data are from INEGI (www.inegi.gob.mx). The Tradable price index is the unweighted arethemetic average of the price indices of food, clothing, and furniture. The Nontradable price index is the unweighted arethemetic average of housing, health, education, transportation, and other services.

Figure 7: Comparing Predicted and Actual Changes in Inequality



Notes: The standard deviation of the residuals is calculated from the log-wage equations estimated from household data quarter-by-quarter using ENEU,ENE, and ENOE data. Differences in datasets required that a level adjustment of the standard deviation be applied to 2001 and 2004-2011 that did not affect the trend in those periods. The predicted earnings variance is the variance of the predicted wages within sector *a* of the model when simulated using the Mexican real exchange rate as described in the text. The correlation between the two series prior to 1998 is -0.83 and the correlation between the two series after 1997 is 0.82.

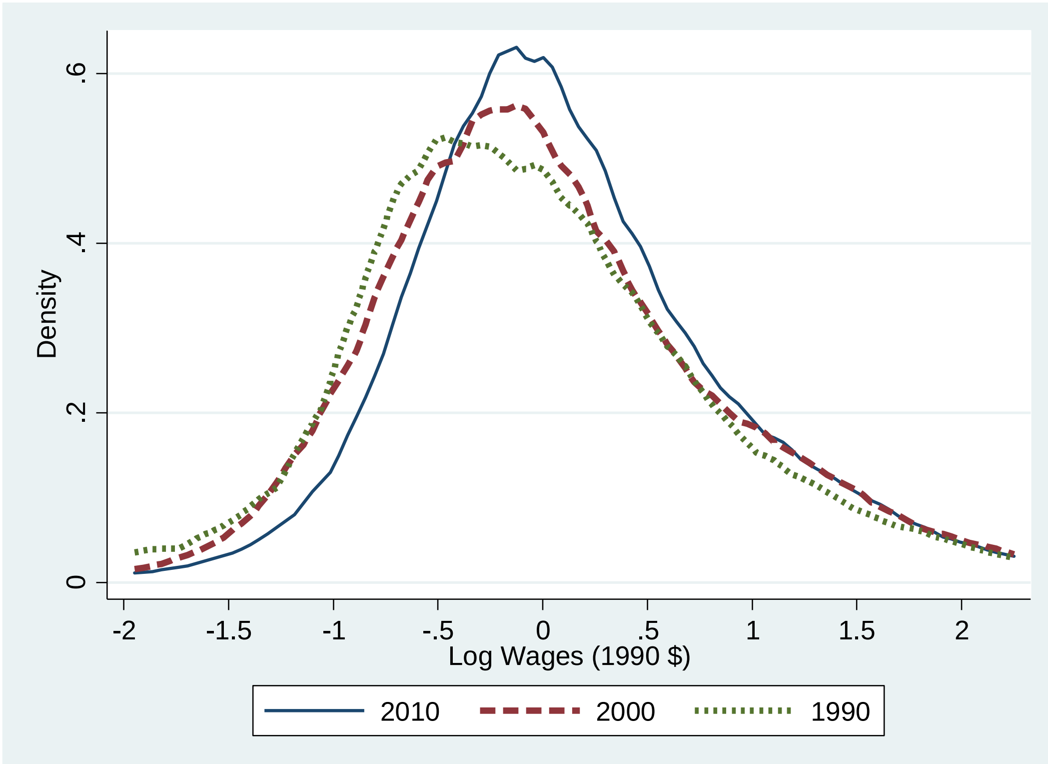
Figure 8: Predicted and Actual Share of Employment in Tradable Sector



Notes: The predicted **r**esults are from the simulation of the Salter-Swan model using the Mexican real exchange rate. The actual is from the ENOE (and related surveys as described in the text). The ENOE industry codes change significantly in 2005, making sector-level comparisons less reliable.

Figure 9: Wage Densities 1990-2010

Panel A: Log Wages



Panel B: Log Wage Residuals

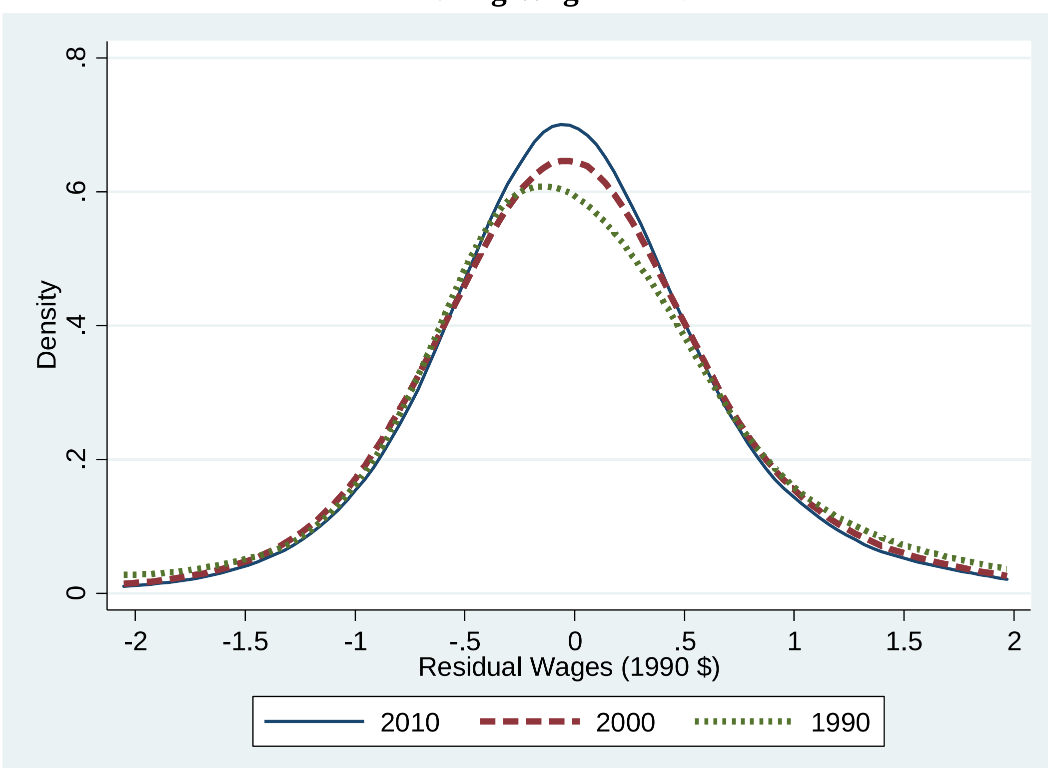
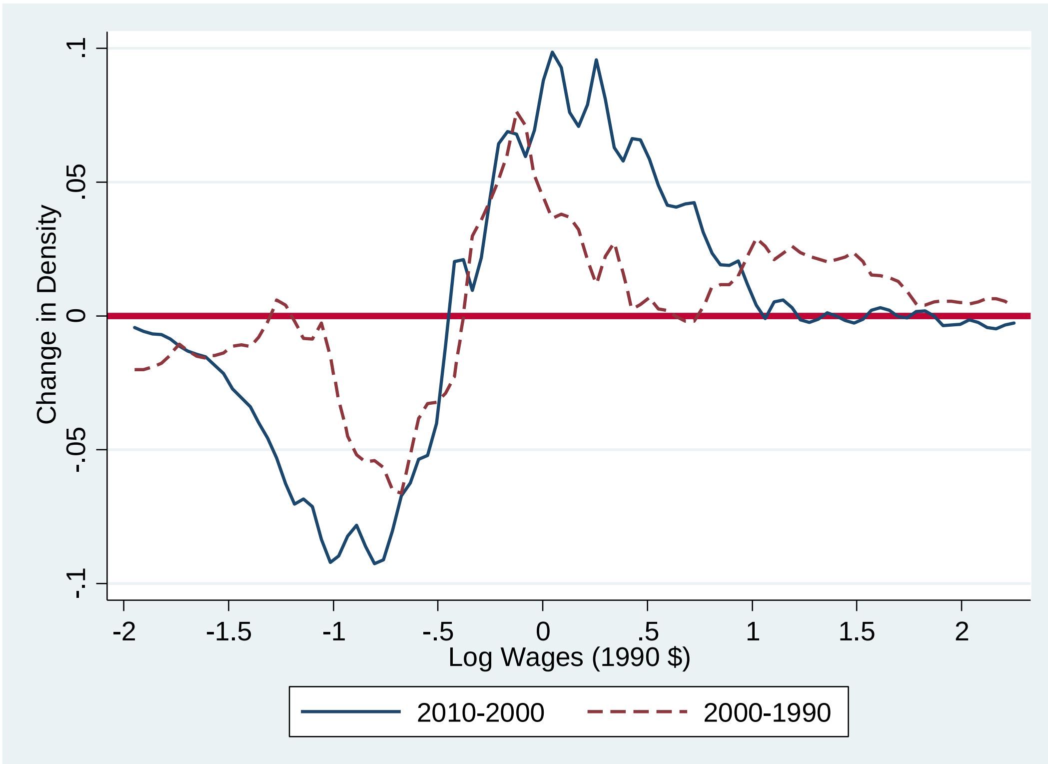


Figure 10: Wage Density Changes: 2010-2000 and 2000-1990

Panel A: Log Wages



Panel B: Log Wage Residuals

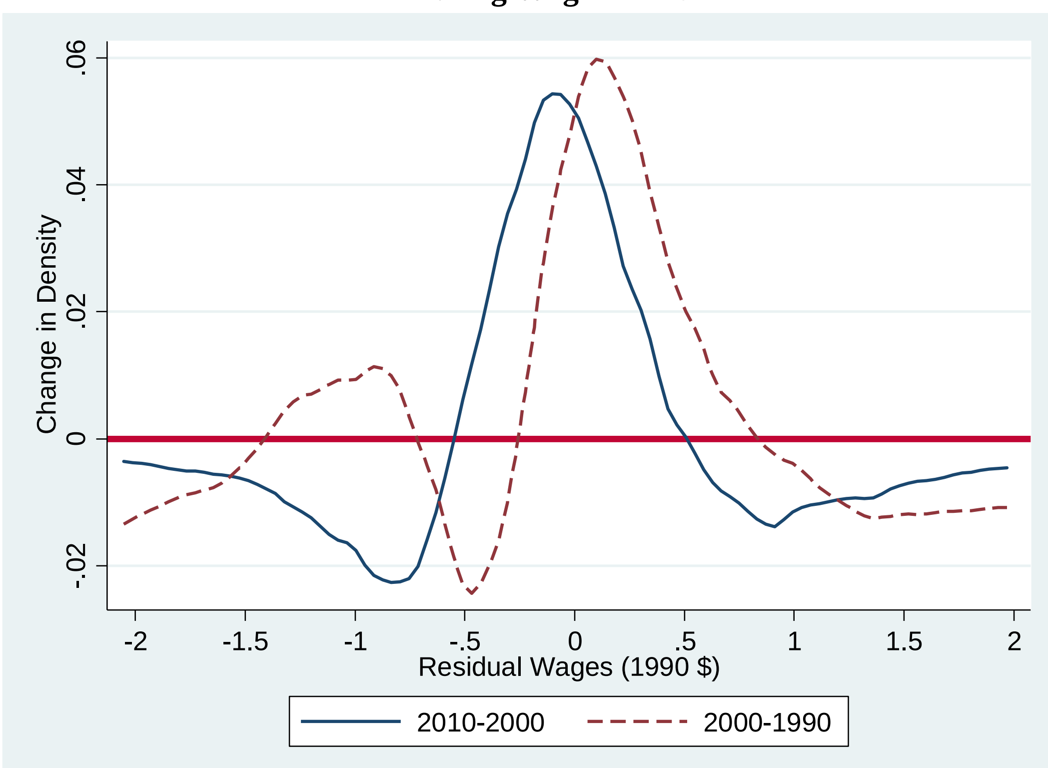
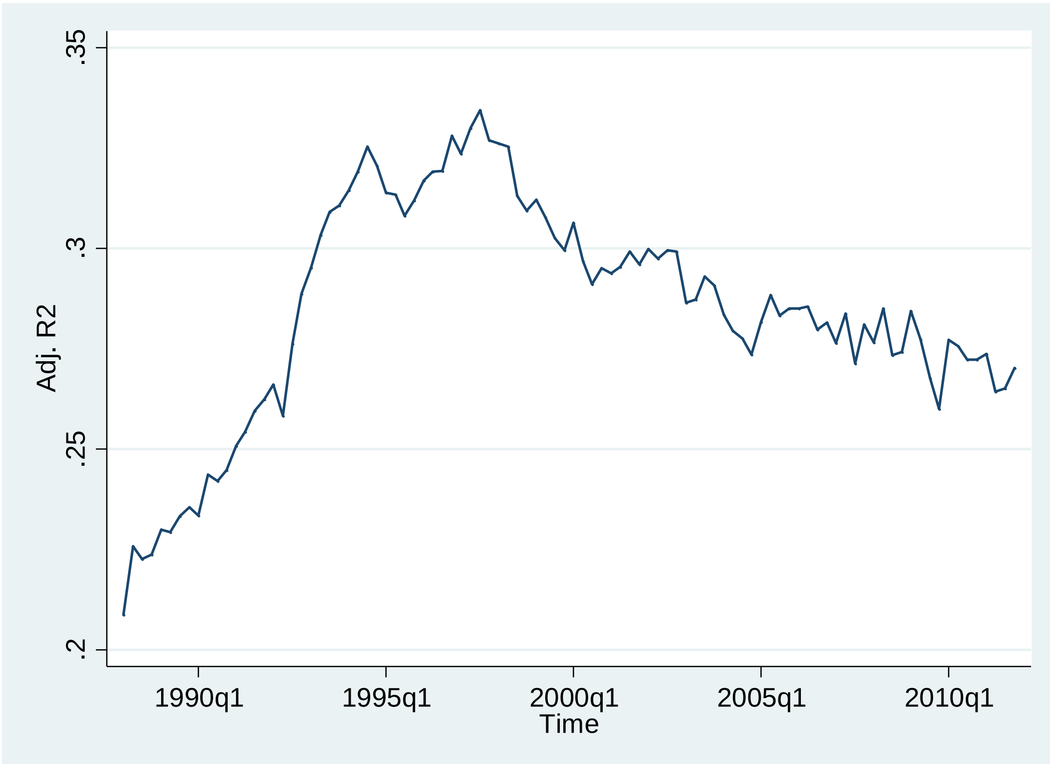


Figure 11: R-Squared from Mincerian Wage Equation
(Quarter-by-Quarter Estimation)



Notes: Adjusted R-squared value from ENEU-ENE-ENOE household data regression of log wages on education, a full set of industry dummy variables, age, and age squared on a sample restricted to males ages 18-65.