Relative Prices and Wage Inequality:

Evidence from Mexico

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Abstract: This paper examines the link between relative goods prices and relative wages during two periods of Mexico's trade liberalization. The relative price of skill-intensive goods rose following Mexico's entrance to the GATT in 1986, but fell after Mexico entered the NAFTA in 1994. This paper adds a band pass filter to two established techniques to compare the relationship between prices and wages. Results from all three approaches are consistent with a positive long-run relationship between relative output prices and relative wages. The band pass filter results suggest that the relevant time frame for the relationship begins after 3-5 years.

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Abstract: This paper examines the link between relative goods prices and relative wages during two periods of Mexico's trade liberalization. The relative price of skill-intensive goods rose following Mexico's entrance to the GATT in 1986, but fell after Mexico entered the NAFTA in 1994. This paper adds a band pass filter to two established techniques to compare the relationship between prices and wages. Results from all three approaches are consistent with a positive long-run relationship between relative output prices and relative wages. The band pass filter results suggest that the relevant time frame for the relationship begins after 3-5 years.

Over one hundred recent papers analyze the relationship between globalization and wage inequality. Few examine the link between relative output prices and relative wages that is predicted by trade theory. The Stolper-Samuelson theorem, a standard result in trade theory, links changes in goods prices and changes in relative factor prices. Starting with the Stolper-Samuelson theorem, this paper considers three issues that arise in the trade and wages debate. The first issue is whether changes in relative prices can explain changes in relative wages. The second issue is whether changes in tariffs and trade policy explain movements in relative prices. The third, raised by Slaughter (2000), is when changes in relative prices affect relative wages.

To examine these three questions, this paper examines two distinct periods of Mexico's trade liberalization. Revisiting the Mexican case is important for two reasons. First, Mexico is more like the classical "small country" assumed in many trade models. For example, Mexico's economy is about $1/17^{th}$ the size of the United States economy. While only about 9.1% of U.S. merchandise exports and imports are with Mexico, over 74.5% of Mexico's imports and 84.0% of Mexico's exports are with the United States. The true advantage of, and evidence suggestive of, Mexico's "small country" status is that the change in relative prices is traced to the "exogenous" shock of tariff reduction. Unlike the United States, whose changes in relative prices are affected by technology and several other factors, the speed and extent of Mexico's liberalization presents a potentially more direct example of the link between trade liberalization and relative wages through changes in relative goods prices.

Second, Mexico's liberalization can be divided into two distinct periods. Mexico first opened trade to an arguably less-skill abundant world (Wood 1997) when it joined the General Agreement and Tariffs and Trade (GATT) in 1986. The main effect of the GATT was a dramatic reduction in tariffs. Mexico then further liberalized trade with skill-abundant Canada and the United States by joining the North American Free Trade Agreement (NAFTA) in 1994. NAFTA further reduced tariffs and fostered deeper North American integration by harmonizing standards, facilitating capital flows, and other measures.

This paper uses three approaches to evaluate the link between changes in relative prices and changes in relative wages in Mexico. I apply both consistency checks (Krueger 1997, Lawrence and Slaughter 1993, Sachs and Shatz 1994, Schmitt and Mishel 1996) and mandated wage equations (Baldwin and Cain 2000, Baldwin and Hilton 1984, Haskel and Slaughter 1999, Krueger 1997, Leamer 1998) found in these price studies. To evaluate the link between tariff changes and wages directly, I apply the two-stage modification of the mandated wage approach proposed by Feenstra and Hanson (1999). Third, Slaughter's (2000) question, "How fast does the Stolper-Samuelson clock tick?" suggests that time series approaches are relevant for the debate. I introduce the band pass filter to the literature to provide one of the first estimates of the relevant time frame for the price-wage relationship.

This paper presents three main findings. First, this paper supports earlier papers that find rising wage inequality after Mexico joined the GATT and extends these papers by showing that wage inequality reversed course and began to fall after NAFTA. The paper's second finding is that the relative price of skill-intensive goods rose following entrance to the GATT, but, after NAFTA, the relative price of skill-intensive goods fell. These price changes are consistent with the change in tariffs that occurred under the GATT and endowment-based expectations of Mexico's integration with its skill-abundant northern neighbors. Third, the band pass filter results suggest that the relationship emerges in 3-5 years and grows closer over time.

This paper supports and extends earlier work on Mexico's trade liberalization (e.g. Hanson and Harrison 1999, Revenga 1997, Cragg Epelbaum 1996). Hanson and Harrison (1999) find that Mexico protected less-skill-intensive industries before entering the GATT and tariff reductions were larger for less-skill-intensive industries, but they do not find significant evidence of a link between changes in output prices and wages. This paper finds strong and consistent evidence of that link. In addition, this paper is one of the first to document changes in the post-NAFTA period. When Mexico joined the GATT, it opened its borders to trade with an arguably labor-abundant world, which may explain why it protected less-skill-intensive industries. Joining NAFTA, however, deepened integration with skill-abundant countries (the United States and Canada). The relative prices of skill-intensive goods reversed its rise. As suggested by the Stolper-Samuelson theorem, relative wages also reversed their trend.

The paper has four sections. In Section I, I briefly review the formal derivation of the Stolper-Samuelson theorem and discuss previous applications of this theorem in the literature. These results provide a foundation for the rest of the empirical analysis. In Section II, I use three independent data sets to document the change in wage inequality before and after NAFTA. In Section III, I show that i) the dramatic change in the tariff structure under GATT is consistent with product price movements, ii) the change in relative wages is consistent with the change in relative prices, and iii) the relationship between relative prices and relative wages emerges in 3-5 years and grows over time. I offer conclusions in Section IV.

I. Relative Prices and Relative Wages: Theory and Practice

The neoclassical Heckscher-Ohlin framework suggests that changes in trade policy affect wages through changes in relative goods prices (Stolper and Samuelson 1941). The Stolper-Samuelson (SS) theorem is a standard result in trade theory and therefore is only briefly reviewed here. Representing the unit costs as a function of factor prices *c(**w**)*, output prices as $\boldsymbol{p}$, output volume as y and factor endowments with the vector $\boldsymbol{v}$, we can express the initial assumptions of perfect competition and full employment as

$$\begin{aligned} c(\mathbf{w}) &= \mathbf{p} \\ \sum_i c_w(\mathbf{w}) y_i &= \mathbf{v} \end{aligned} \qquad (1)$$

These conditions are totally differentiated and solved to express the change in factor prices as a function of product prices. The penultimate result is

$$\hat{p} = A\hat{w} \qquad (2)$$

in which A is the matrix of factor cost shares and the circumflexes (^) indicate percentage changes.

The *Essential Version* of the SS theorem is derived neatly when A is square and invertible (as in the two-good, two-factor case). The matrix A is inverted to yield a direct relationship between exogenous prices and endogenous wages. Most empirical studies, however, use data from many industries while considering at most four factors. Since the resulting factor share matrix A is not square, a common empirical response is to appeal to the *Correlation Version* of the Stolper-Samuelson Theorem (Deardorff 1994). The Correlation Version acknowledges that, for a given change in the price vector, it is impossible to say exactly which factor return will rise and which will fall. There should, however, be a correlation between the vectors of goods price changes and factor price changes.

Three broad empirical approaches relate changes in prices and changes in wages in the literature. The first approach applies "consistency checks" to changes in relative prices and relative wages. The Correlation Version (and more strict interpretations) suggest that, in order for output price changes to increase wage inequality, the price of skill intensive goods must rise relative to the price of less-skill intensive goods. Equations (1) and (2) implicitly harbor the "small, open economy" assumption in which prices are exogenous (productivity and other factors that affect domestic prices are assumed away). Studies that examine the factor intensity and timing of price changes have been called "consistency checks" because positive findings suggest that changes in prices and changes in wages are consistent with the Stolper-Samuelson theorem.

Leamer (1998) uses the term "mandated wage equations" to describe the second empirical approach. Mandated wage equations predict the change in wages that would be consistent with Stolper-Samuelson effects. The basis for this approach is the idea that cross-industry product-price changes should be proportional to common-across-industries factor-price changes where the factor of proportion is the industry's factor shares. The idea behind this approach is that since the factor share matrix in (2) is not invertible, one can estimate (2) directly. A wage vector is estimated by regressing the vector of price changes across time on the factor share matrix. The estimated vector is then compared to actual wage changes. Feenstra and Hanson (1999) argue that when the mandated wage equation is fully specified, it becomes an identity that cannot predict any change in wages other than what actually happened. They propose a two-stage modification that can identify the change in wages that is due to changes in policy, such as tariff changes.

Francois and Nelson (1998) and Francois, Navia, and Nelson (1998) argue that (2) implies that prices and wages exhibit a long-run relationship. Applying cointegration techniques, they find evidence of a relationship between relative prices and relative wages through time in the United States. Equations (1) and (2) lack adjustment costs and therefore are most applicable in the long run. The theory provides little help in determining the length of real time that constitutes the "long run." After establishing the intuitive result that relative prices and relative wages are both stationary series, I employ a band pass filter technique to generate evidence on the relevant timeframe for the prices/wages relationship.

II. Relative Wages in Mexico 1987-1999

To illustrate the change in wage inequality before and after NAFTA, I use three sources of data provided by Mexico's National Institute of Geography, Information, and Statistics (*INEGI*): the Mexican Industrial Census for the manufacturing sector, the National Urban Employment Survey (or ENEU, from its Spanish acronym) from eight Mexican metropolitan areas[1] of Mexico, and the Mexican Monthly Industrial Survey (*Encuesta Industrial Mensual, or* EIM).

The Mexican Industrial Census is conducted every five years and contains information on the employment of production workers (*obreros*) and nonproduction workers (*empleados*), as well as aggregate payments to each type of worker. I calculate the employment-weighted nonproduction/production per-worker wage ratio for census years 1985, 1988, 1994, and 1998.[2] The path of relative wages is shown in figure 1a. Feenstra and Hanson (1997) use Mexican industrial census data to show the increase in wage inequality that followed GATT membership. Figure 1 is consistent with their figure in that wage inequality increases between 1988 and 1994. After NAFTA, however, wage inequality falls.

[1] Mexico City, Mexico State, Monterrey, Guadalajara, Tijuana, Ciudad Juarez, Nuevo Laredo, and Matamoros.

[2] Prior to 1988, the census years were evenly divisible by 5.

The Industrial Census covers manufacturing. To examine a more comprehensive measure of wage inequality, I calculate the returns to education using the ENEU. Analogous to the United States Current Population Surveys, the Mexican ENEU is a quarterly household-level survey used to calculate unemployment statistics. For working-age employed males and females, I estimate the returns to education in a log-wage equation for each quarter from 1987 through 1998. [3] Figure 1b shows that the return to education follows a path similar to that in figure 1a. Although somewhat delayed, the returns to education fall after NAFTA.

Evidence that trade may be linked to the change in the demand for skill might be identified by comparing the return to education in Mexico's border region with Mexico's interior region. Robertson (2000) shows that the border region is more affected by United States labor markets than the Mexican interior, which may be due to migration, transportation costs, capital flows, or trade. Figures 2a and 2b compare the time-path of the return to education in the border and the interior. Both series rise and then fall, but the change in the border region occurs closer to the NAFTA date. Note that this may suggest forces at work in addition to those suggested by Feenstra and Hanson (1997), because employment in the maquiladora sector[4] rises continuously over this sample period.

A third source of data is the Monthly Industrial Survey (EIM). The survey includes data on production and nonproduction employment and wages, employment hours for each worker type, the value of production, and the value of sales. Unfortunately, the data do not include information on capital or intermediate inputs. As in United States industrial surveys, larger firms have a higher probability of remaining in the sample over time. The survey excludes firms in the maquiladora industry. The exclusion of maquilas may allow me to identify effects that are separate phenomena

[3] The return to education was estimated as the coefficient on a continuous years-of-education variable from a log-wage equation using the pooled ENEU data. Separate equations were estimated for each quarter. The relative wage data are shown in figure 6.

[4] The maquiladora industry, or in-bond industry, is composed of the group of plants allowed to import parts for assembly duty-free and then export the finished product. Tariffs are only paid on value added in Mexico.

than the foreign investment effects on relative wages identified by Feenstra and Hanson (1997). Table 1 contains the summary statistics from the EIM by two-digit industry.[5]

I follow Lawrence and Slaughter (1993) and divide the EIM industries into those that intensively use production workers and those that intensively use non-production workers. Use of the production/non-production distinction as a proxy for skill intensity has been criticized in U.S. studies. In Mexico, however, this distinction seems to capture much of the skill segregation between industries. The last three columns in table 1 use *ENEU* data to show that production workers have less education in every industry than non-production workers. Industries with higher relative employment ratios also have higher average education levels. Both Kendall and Pearson rank-correlation tests reject the hypothesis that the two measures (education and the non-production/production ratio) are independent at the 0.0001 level. Using the production/non-production distinction to (imperfectly) classify skill intensity seems valid in the Mexican case.

The EIM is the primary data set used in this paper because, in addition to its high frequency, it also contains production value and quantity that can be used to compute unit values. I aggregate the unit values into industry-level Laspeyeres and Paasche price indices. I classify the Mexican manufacturing industries into two groups based on the median ratio of production to non-production workers.[6] Using this classification, I then calculate the production-weighted ratio of the output price indices of the two groups. Figure 3 shows the movements of relative prices and relative wages. The employment weighted hourly nonproduction/production wage ratio is used to proxy for relative wages. The two series follow closely together throughout the sample. They also follow the same general path as the returns to skill measured with industrial census data and household-level surveys (figures 1 and 2).

[5] The surveys also exclude firms with less than 6 employees. The data do not include information on temporary or unpaid workers. Unpaid workers include apprentices and family members. In 1988, unpaid workers made up only about 10% of manufacturing employment.
[6] Using the top and bottom thirds of the employment ratios generates similar results.

The rise in inequality between 1987 and 1994 are consistent with the findings of Cragg and Epelbaum (1996), Revenga (1997), and Hanson and Harrison (1999).[7] The fall after NAFTA, however, is not included in these earlier papers. These papers attribute the rise in wage inequality to a rising demand for skill, but none of these papers link changes in output prices and changes in wage inequality.

III. Tariffs, Relative Prices, and Wage Inequality

Equation (2) suggests that changes in relative prices can help explain changes in relative wages. A positive relationship between changes in tariffs and relative prices supports the hypothesis that the change in relative wages is linked to trade. This section presents two key findings. Using new data, I affirm Hanson and Harrison's (1999) finding that, prior to GATT, Mexico protected less-skill-intensive industries and, when Mexico joined GATT, the relative price of skill-intensive goods increased. In contrast to earlier papers, I show that the change in wages is directly linked to the change in tariffs through changes in prices. I also extend earlier results by showing that Mexico is less-skill abundant than the United States and that, when Mexico joined NAFTA, the relative price of skill-intensive goods fell.

A. The Structure of Protection Before and After the GATT

Mexico turned from import substitution industrialization (ISI) in the early 1980s by liberalizing foreign investment laws. The strongest sign of Mexico's commitment to ending ISI was its 1985 announcement to join the General Agreement on Tariffs and Trade (GATT). Perhaps in anticipation of the GATT, tariffs increased between 1984 and 1985. When Mexico joined the

[7] Currency movements also influenced relative prices, confounding the effects of tariff changes. Mexico's peso was devalued in 1987, which made imports more expensive and afforded import-competing industries some relief from the reduction in trade barriers. The peso's ill-fated overvaluation began to accelerate after 1990, and the trade balance took a sharp negative turn. The tariff reductions would have been "felt" more strongly after 1990.

GATT in 1986, it began to dramatically reduce trade barriers. Tariffs fell dramatically until 1988, at which time they increased slightly and stabilized.

Hanson and Harrison (1999) use a survey of large firms to compare factor intensity and the pre-reform structure of protection. I affirm their results using industrial census data. The relative employment data come from the 1985 Mexican Industrial Census, the closest census to the 1986 reforms. The census employment data are matched to the average most-favored-nation (MFN) tariff rates for Mexico in 1985.[8]

Figure 4 graphs the 1985 MFN tariff rates as a function of the relative employment of non-production to production workers. The fitted lines are estimated with and without weights (using total industry employment as weights). The estimated slope (standard error) is -17.388 (8.311) without weights and -25.795 (7.862) with weights. There is a clear negative relationship between 1985 tariff levels and the share of non-production workers. Figure 5 shows the change in tariffs as a function of relative employment. The unweighted slope (standard error) is 13.329 (7.050) and the weighted slope (standard error) is 18.428 (6.787). These results also are consistent with Hanson and Harrison: industries that intensively use production workers experienced larger tariff declines.

B. The Structure of Protection Before and After the NAFTA

One explanation for why Mexico protected less-skill intensive industries is that, relative to the world, Mexico is not skill-scarce. While Mexico's skill endowment relative to the world may be difficult to establish with certainty, Mexico is not skill abundant relative to the United States. Figures 6a and 6b show the distribution of education in Mexico and the United States using

[8] I thank Antoni Estevadeordal of the IADB for the tariff data. The tariff data are the unweighted average most favored nation (mfn) applied tariff rates. The census employment data were aggregated to the 4-digit ISIC Rev. 2 level to match the tariff data.

household surveys.[9] These figures suggest that the United States is skill-abundant relative to Mexico.

NAFTA, which went into effect on January 1 1994, is a more comprehensive agreement designed to deepen North American economic integration. The maximum effective tariff in manufacturing prior to the GATT was just under 80%. The maximum tariff prior to NAFTA was 20%. NAFTA includes additional tariff reductions, but also contains provisions designed to facilitate capital flows, conflict resolution, harmonization of standards, and other measures designed to deepen integration. Under the agreement, Mexican tariffs on all industrial goods from the United States and Canada will be zero by 2003 (a few tariffs on agricultural products will be phased out over 15 years). The reduction in tariffs on United States and Canadian goods occurs in three stages. Some products (Category A) became duty-free immediately as of January 1994. Others (Category B) experience five equal reductions of 20 percent a year, so that these items were duty-free in 1998. Goods in the third category (Category C) experience 10 equal reductions of 10 percent a year, so that these items are duty-free in 2003. Category D goods were already duty-free before NAFTA.[10] One exception is Textiles, which are coded "A," "B6," and "C." For these products, A and C are the same as above. B6, however, means that in the first year, tariffs are reduced by the same amount as the duty (i.e. if the duty is 20%, the tariff elimination the first year will be 20%), and then the duty will be reduced in equal portions across the remaining five years, with the good becoming duty free in 1999 (not 1998, as in the intermediate staging for other goods).

To examine the relationship between skill intensity and tariff changes in the NAFTA, I first sort the products into tariff categories in increasing order of protection (D, A, B, B6, B+/B1, C). I then estimate ordered logit and ordered probit equations of the products' tariff categories on the production worker and nonproduction worker cost shares of each product's industry.[11] Part A of table 2 contains the results in which the industry's employment ratio was assigned to all related

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[9] All twelve months of the Monthly Outgoing Rotation Groups of the United States Current Population Surveys in 1993 generate the result shown in figure 6a. All four quarters of the Mexican *Encuesta Nacional de Empleo Urbano* in 1993 generate the result shown in figure 6b.
[10] See http://www.mac.doc.gov/nafta/6000.htm.
[11] Using the relative employment ratio in place of cost shares generates similar results.

products specified in the NAFTA tariff tables. In every case, the estimated coefficient on the nonproduction cost share is negative and significant, suggesting that industries with a higher nonproduction worker ratio experience a more rapid decline in tariff protection.

Part B of table 2 contains the results in which the products found in the EIM (a subset of the products specified in the NAFTA appendix) are assigned their NAFTA tariff codes. Examining only the products in the EIM reveals a nonlinear relationship between skill intensity and protection. Products assigned an "A" code are generally more skill-intensive than products assigned the "B" codes and are generally less skill-intensive than average. Products assigned a "C" code, however, are nearly as skill-intensive as those assigned an "A" code, giving the impression that protection and skill-intensity have a "u"-shaped relationship. Ordered logit and ordered probit estimation on these products generates coefficients that lead to the opposite conclusions as those in part A of table 2: the estimated coefficient on the production cost share is generally negative, significant, and larger than the estimated coefficient on the nonproduction cost share. Furthermore, within the "A" classification, skill intensity is positively associated with larger tariff reductions. These results contrast with the results in part A and the observation that "A" products have a higher average skill intensity than "B" products which imply that tariffs first fell on skill-intensive goods following the implementation of NAFTA.

These mixed results suggest that the relationship between tariff changes and price changes was not as monotonic under NAFTA as it seemed to be under GATT. Tariffs on less-skill-intensive goods were higher and fell faster after the GATT. Tariffs on skill-intensive goods were scheduled to fall faster in the first stage of NAFTA than in the second stage, but within the first stage there was a larger reduction in tariffs of less-skill-intensive goods. If these tariff changes affected relative prices, the relative price of skill-intensive goods should have risen after the GATT and NAFTA. If the broader integration measures under NAFTA affected prices more than the tariff changes in ways consistent with factor endowments (skill-intensive goods are less expensive in skill-abundant countries), then the relative price of skill-intensive goods should have fallen after NAFTA. The time series in figure 3 suggest that the relative price of skilled goods rose after the

GATT but fell after NAFTA, but the next step is to formally verify the link between price movements and skill intensity and compare the price movements to tariff changes.

C. Consistency Checks of Price Movements and Skill Intensity

To compare price movements over the 1987-1999 period, I first divide the period into two using January 1994 as a dividing point. As in Lawrence and Slaughter (1993), I regress the change in prices (dP_j) over each sample period on the ratio of non-production to production workers (H/L) at the beginning of each sample period:

$$dP_j = a + b(H/L)_j + e_j \qquad (3)$$

To estimate (3) I use Industrial Survey output and product-price data. Following Hanson and Harrison (1999), I deflate the price data with the Mexican CPI. Details of the construction of the price data are found in Appendix A.

Table 3 presents the regression results for the Mexican data for each period of trade liberalization.[12] Each regression is estimated using weighted least squares using the mean value of output over 1987-1998 as weights.[13] The results in table 3 suggest that there is a significant and positive relationship between skill intensity and the change in the output price for the first period of liberalization (1987-1993 and 1988-1993). This evidence indicates that the relative price of non-production-worker-intensive goods rose relative to the price of production-worker-intensive goods. The results are robust to using education as a measure of skill. The second two columns suggest that the pattern of price change reverses after NAFTA. The change over the 1993-1998 period is

[12] Using U.S. data and without controlling for the computer industry, Lawrence and Slaughter (1993) find either a negative or zero estimate for b and conclude that the relative price of non-production worker intensive goods did not increase over the sample period. Using a similar approach, Sachs and Shatz (1994) control for the computer industry and find a positive correlation. Krueger (1997) uses U.S. data from 1989-1995 and finds a positive correlation with and without controlling for the computer industry. Slaughter (2000) discusses the robustness of results found with and without computer-industry controls.
[13] Krueger (1997) uses weights and Slaughter (2000) discusses the robustness of using weights. They are appropriate for the Mexican case because of the large variance in industry employment.

significant at the 10% level and the relevant coefficients in both columns reverse sign: they are positive in the GATT period and negative following NAFTA. These results suggest that the relative price of skill intensive goods fell when Mexico opened to trade with relatively skill-abundant Canada and the United States.

Another consistency check is not strictly necessary for the presence of Stolper-Samuelson effects but, if present, may help explain the change in demand for skill. As an industry's relative output price increases, that industry's output share should also increase (thus increasing the demand for factors employed in that industry). Several authors[14] examine the change in demand for skill between and within industries. A change in relative prices that causes a shift in resources towards industries that expand emerges as an increase in demand between industries. To examine this phenomenon in Mexico, I decompose the change in the demand for skilled workers between and within industries using the familiar decomposition:

$$\Delta E = \sum_j \bar{s}_j \Delta e_j + \sum_j \bar{e}_j \Delta s_j \qquad (4)$$

(total = within + between)

where ΔE is the change in employment-weighted average of non-production to production workers for manufacturing between 1987 (averaged across all months) and both 1994 and 1995 (averaged across all months), s_j is the employment share of each industry j, and e_j is the ratio of non-production to production workers in each industry (with a bar, these variables represent the mean over the sample period). The first term on the right side is the change within industries. The second term captures the change between industries. If factor supplies were fixed and all economic sectors were included in the decomposition, the left-hand side would be zero. This is assumed by the Heckscher-Ohlin theorem and this decomposition shows why trade theorists argue that a within-industry increase in the relative employment of skilled workers is inconsistent with a trade-based explanation for the rise in wage inequality. A change in relative prices could cause a between-industry shift towards skilled workers, which, given fixed factor supplies, would have to be offset

[14] See, for example, Berman, Bound, and Griliches (1994) and Autor, Katz, and Kruger (1998).

by a decline in the employment ratio within industries. When looking at a particular sector, the assumption of fixed factor supplies does not hold if workers can move between sectors.

Nonetheless, looking at the manufacturing sector is informative because tradable industries were the most affected by trade liberalization. The values for this decomposition over the period 1987-1994 are 0.028 = 0.012 (between) + 0.016 (within). Over the period 1987 to 1994, the relative employment of non-production workers increased 2.8 points, an increase of 6.0%. The decomposition reveals that the change in skill demand over the 1987-1994 period was about equally divided between *between* and *within* effects. The values for this decomposition over the period 1993-1998 are -0.028 = -0.009 (between) + -0.019 (within). Over the second period the relative employment of non-production workers fell the same amount as it increased in the first period and the between-industry shift played an important role in both periods. Again we see a reversal in the demand for skill following NAFTA.

The change in price that followed the GATT is consistent with the Stolper-Samuelson theorem in the sense that the increase in the relative wage of skilled workers was preceded by an increase in the relative price of skill-intensive goods. In addition, it appears that, as a response to the change in relative prices, skill-intensive industries expanded. Following NAFTA, however, the demand for skill reverses, as Mexico liberalized trade with its more skill-abundant North American neighbors. Again, although not technically part of the Stolper-Samuelson theorem, changing employment patterns may help understand the changing demand for skill.

These findings do not, however, directly support the relationship represented in (2). Ideally, solving equation (2) for wages as functions of prices and estimating these functions would determine the effect of changes in prices on wages, but dimensionality makes solving (2) difficult. Specifically, (2) can only be solved when there are an equal number of goods and factors and even then it does not give clear results when the number of goods and factors exceeds two. In the next two sections I apply two approaches that have been suggested in the literature.

D. The Mandated Wage Approach

To test the long-run relationship between wages and prices, the mandated wage approach estimates (2) and compares predicted changes in wages with actual changes. Baldwin and Cain (2000) interpret (2) with the following regression equation:

$$\hat{p}_j = a + \sum_i \hat{w}_i q_{ij} + e_j \qquad (5)$$

in which i is the factor index and q is the share of factor i employed in industry j. The variables p_j and w_i represent the output price in industry j and the economy-wide return to factor i respectively. In this approach, the factor shares are the independent variables and the prices are the endogenous variables. In this sense, the estimation deviates from a strict interpretation of the theory. The parameters to be estimated are the changes in the wages (over the sample period) that are assumed to be equal across all industries because factors are assumed to be perfectly mobile across industries. If the predicted changes match the actual changes, then Stolper-Samuelson effects are said to have a large contributing role in determining wages. If the match is poor, then the direction of the difference suggests either other factors, such as changes in technology, or an omitted-variable bias.

The United States literature identifies four key estimation issues. The first concerns the exogeneity of price changes. Technology affects prices and therefore affects wages. If technology is changing, and technology affects prices, then failure to account for technology leads to biased results. One advantage of studying the Mexican case is that prices and technology may be more likely to be exogenous than they are in the United States in the sense that prices can be more closely linked to tariff changes. Evidence from the previous two sections suggests that the price movements are consistent with the large tariffs reductions that occurred under the GATT.

The ambiguous result following NAFTA suggests more detail is necessary to examine the exogeneity of technology in Mexico. In 1992, INEGI conducted a firm-level survey of 5071 manufacturing firms.[15] The survey includes questions about technology investment and acquisition. According to the survey, the average share of revenues allocated for research and development was 0.6% in 1992 while the average share of revenues allocated for technology purchases was 3.1% in 1992 (up from 2.5% in 1989).[16] 64% of firms with more than 100 workers purchased their technology from abroad and over 37% purchased their technology directly from the United States. Furthermore, only 2.6% of all firms in the survey reported using a "cutting-edge" productive process, with the rest having either a "mature" or "older" process. Given that Mexico is a developing country that tends to import technology, it seems reasonable to assume that technological improvements are first realized by the developed countries, affect prices in the developed countries, and then get passed to the developing countries both directly and through product prices.

The second estimation issue involves value-added prices. Slaughter (2000) shows that intermediate inputs make up large and growing shares of production in the U.S. Accounting for the prices of intermediate inputs is especially important when intermediate inputs are imported because changes in the prices of intermediate inputs are passed through to product prices and can thus affect factor prices (Woodland 1982). Unfortunately, the industrial survey data do not include information on intermediate inputs. Thus, when using the industrial survey data, I am forced to use "gross" output prices rather than "net" output prices. To check the robustness of these results, I introduce information on intermediate inputs from the Mexican *Industrial Census*. The correlation between the value-added prices changes and the gross-output price changes is 0.9033. The findings are qualitatively robust to using value-added prices and accounting for intermediate inputs.

Feenstra and Hanson (1999) introduce two additional estimation issues. They argue that when the mandated wage equation includes inter-industry wage differentials and productivity, the equation becomes an identity and therefore the estimated coefficients in (5) cannot reveal anything

[15] The National Survey of Employment, Salaries, Technology, and Training in the Manufacturing Sector (*Encuesta Nacional de Empleo, Salarios, Tecnologia, Capacitacion en el Sector Manufactuero, 1992*) was a joint project between INEGI, Mexico's Labor Secretariat, and the OIT.

[16] For comparison, on average, U.S. industry spent 3.1% of net sales on R&D in 1989 (National Science Foundation, 1992).

about the change in wages other than that which actually occurred. They introduce a two-stage procedure that can be used to identify the contribution of changes in trade policy to changes in relative wages.

I address these issues in two ways. In Haskel and Slaughter's (1999) study of U.K. wage inequality, they argue that inter-industry wage differentials are stable in Great Britain and so do not affect the analysis. Abuhadba and Romaguera (1993) compare individual level data for Chile, Uruguay, and Brazil and find "more similarities than differences" with IIWDs observed in U.S. data aggregated over workers, suggesting that inter-industry wage differentials may be stable in Latin America as well. If inter-industry wage differentials are stable and technology does not affect prices, then the mandated wage approach may be appropriate for Mexico. Secondly, I apply Feenstra and Hanson's two-stage approach to identify the contribution of the tariff changes on relative wages.

I first estimate equation (5) for the period following the GATT and again for the period following NAFTA. In the first case, I use the average factor shares in 1987 and 1988 and the change in the output price index for each industry over the period 1987-1993 and 1998-1993. In the second case I use average factor shares from 1993 and 1996 and the change in the output price index for each industry over the period 1993-1998 and 1996-1999. I examine the 1996-1999 period because a deep recession began with the collapse of the peso in December 1994 and began to end in 1996. Following Baldwin and Cain (2000), I use the value of industry output as regression weights.

The actual changes in average hourly wages and the results from (5) are found in table 4. Although imprecise, all of the point estimates are consistent with the Stolper-Samuelson theorem and the predicted changes are similar to the actual changes. For both regressions covering the post-GATT period, the predicted change in wages for production workers is large and negative while the predicted change in non-production wages is large and positive. In all cases, the predicted changes in wages are larger than the actual changes. In only one case are the predicted changes statistically different from the actual changes (production workers over the 1988-1995 period). In this case, the predicted change in wages is large and negative, while the actual change is close to zero. While the large standard errors may suggest that the null hypothesis (that predicted changes and actual changes are similar) is difficult to reject, the actual wage change for non-production workers is outside the 95% confidence interval for the predicted wage of production workers in all four cases.

The relative magnitudes reverse following NAFTA, suggesting a predicted fall in wage inequality. In the period following the crisis, the predicted wage change for both types of workers is negative. The predicted changes match the actual change in wages in that both suggest that the relative wage of skilled workers fell following NAFTA. The negative wage changes may have been the result of the peso-induced recession. The predicted changes for the 1996-1999 period are positive but again the predicted changes match the actual wage changes in suggesting a fall in wage inequality. The predicted changes in the 1996-1999 period are statistically significant. This may be consistent with the idea that the effects of prices on wages take some time to emerge.

Although the point estimates in table 4 are consistent with the predicted effect of prices on wages, there are several reasons to be concerned about the results. First, as noted earlier, the survey data used for these results do not include intermediate inputs, such as capital and materials. The Mexican Industrial Census contains these data for 54 four-digit industries for 1985, 1988, and 1993 (later years were not yet available). Price data from the Survey match 45 Census industries for 1988 and 1993. The Census data allow me to construct value-added price measures by multiplying the price index by (1 - share of materials). Results from estimating (5) with the Census data and value-added prices are found in table 5. The first two columns use the actual cost shares of the factors and the second two columns constrain the cost shares to sum to one. In columns (1) and (3) the dependent variable is the change in value-added prices over the 1988-1993 period. In columns (2) and (4) the dependent variable is the change in value-added prices over the 1987-1994 period (using the 1988 and 1993 data to construct value-added prices for 1987 and 1994).[17]

When technology is included, the predicted change in wages is much closer to those actually observed in Mexico. This is especially true in column (5). The mandated wage equations suggest that the change in relative prices would have caused an even larger increase in wage dispersion had other factors not been at work. Measures designed to protect low-wage workers, not uncommon in Mexico, may have been in effect and deserve further exploration.[18] Overall, however, the coefficients are not measured very precisely, and the necessary aggregation to the census data may contribute to the imprecision.

While the point estimates are consistent with the results generated with the Survey data (once technology changes are accounted for), Feenstra and Hanson (1999) argue that a two-stage procedure is necessary to estimate the contribution of the tariff changes on wages. The first step of this two-stage procedure is represented as

$$\Delta \ln p_{it} = l\, etfp_{it} + b\,'\Delta z_{it} + n_{it} \tag{6}$$

in which ë is the pass-through factor on effective total factor productivity (*etfp*) for each industry *i*. The vector *z* captures changes in exogenous variables that have an effect on prices over and above those due to *etfp*. This, of course, is essentially Feenstra and Hanson's equation (6). In this application, however, we assume that Mexico takes technology as given and therefore the effects of tariffs on prices are the predicted values from (6) when the only element in *z* is the tariffs. This predicted value is then used as the dependent variable in the second stage. The factor shares (production and nonproduction workers) are the independent variables. Thus, the second-stage regression is

$$b\,'\Delta z_{it} = a_1 \overline{pcs}_i + a_2 \overline{ncs}_i + u_{it} \tag{7}$$

in which *pcs* and *ncs* represent the cost shares of production workers and nonproduction workers (the bar above each variable indicates the mean taken over the relevant period).

For the GATT period, the dependent variable in the first stage regression is the change in prices over the 1987-1993 period and the 1988-1993 period. The independent variable (*z*) is the

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[17] There are many reasons to question causality running from technology to prices. For example, several papers have found that positive demand shocks (rising output prices) are correlated with large productivity gains and they attribute this to labor hoarding. See, for example, Anton and Evans (1998).

[18] Bell finds (1997) minimum wages may not contribute to the explanation. Other possibilities include wage agreements between business, labor, and the government that established an effective floor above the legal minimum.

change in tariffs between 1985 and 1988 for each industry included in the monthly industrial survey. The second stage regression results for the GATT period are found in the first two columns of table 6. Both variables in both equations are statistically significant at the 5% level, and both suggest that the change in tariffs increased wage inequality. The estimated magnitudes are much smaller than both the estimates found in table 4 and the actual changes. Compared to the actual changes of nonproduction worker wages, the changes in table 6 suggest that tariffs explain about a third (0.179/0.548) of the rise in the nonproduction worker wage.

For the NAFTA period, I use 874 product-level prices matched to product-level tariffs. The initial tariffs on products whose tariffs were designated to go to zero upon implementation of NAFTA (category "A" products) were used in the first-stage regressions to predict the change in prices that were due to the tariff change. I considered price changes over the 1994:1 to 1994:11 (pre-peso crisis) and the entire period in which data are available (1994-1999). For the second period, I calculated the change in the average unit value for all of 1994 and all of 1999. The results from the second stage regressions are found in columns (3) and (4) of table 6. Consistent with the earlier tariff analysis, the predicted effects on wages suggests rising inequality in the short run. In terms of statistical significance, this is mostly due to the predicted wage reduction of production workers. The size of the initial effect diminishes over time.

Labor market adjustment costs offer one possible explanation for the difference in the GATT and NAFTA periods, but they have received little attention in the literature. Labor market adjustment costs may affect the timing of the relationship between tariffs, prices, and wages and may create a lag between the time that prices change and wages are affected. Labor market adjustment costs are important in Latin America in general (Heckman and Páges-Serra 2000) and are non-zero in Mexico in particular (Robertson and Dutkowsky, forthcoming). Without knowing the relevant timeframe over which prices affect wages, the chosen interval length is somewhat *ad hoc*. The next section applies a time-series approach to generate evidence about the relevant time frame for the relationship between changes in output prices and changes in wages.

E. The Timing of Adjustment

Using two classifications of workers (skilled and unskilled), Francois, Navia, and Nelson (1998) circumvent the dimensionality problem inherent in (2) by dividing industries into two groups based on factor intensity. They follow Borjas and Ramey (1994) and Baldwin and Cain (2000) when constructing their relative wage series and when computing relative prices. Since there are only two factors (skilled and unskilled workers) and only two goods (based on factor intensity), the factor share matrix in (2) can be inverted to yield

$$\hat{w} = \Theta^{-1}\hat{p}\,, \tag{8}$$

which Francois, Navia, and Nelson (1998) interpret as representing the relationship between relative prices and relative wages over time. They then test the hypothesis that relative wages and relative prices are cointegrated. There are two necessary conditions for cointegration. The first is that both series must exhibit a unit root. Although there is little intuitive support for the idea that *relative* wages and *relative* prices should be non-stationary, thoroughness dictates that we consider this first condition. The second is that the difference between the two series be stationary. Only if the first condition is satisfied is the second condition considered.

While figure 3 seems to suggest that the two variables are closely related over time, I sequentially consider each condition for cointegration. I first use the root mean squared error of the regression (RMSE), Akaike's Information Criterion (AIC), Amemiya's Prediction Criterion (PC), and Schwarz's Information Criterion (SC) to determine each variable's optimal lag length. I find that the optimal lag length for prices is 3 and for wages is 4. Given these lag lengths, I then apply the augmented Dickey-Fuller unit root test (with a linear trend) for each variable. Since the test statistics (p-values) are -2.11 (0.242) and -2.39 (0.145), I fail to reject the hypothesis that each series exhibits a unit root.

The linear trend, however, may not be appropriate for the series shown in figure 3. In fact, the appropriate trend is not known. Positive adjustment costs and a potential reversal in the direction of relative prices may suggest that over the time period under study, the two series may exhibit a quadratic trend. Since the actual trend is not known, and since it may affect the unit root tests, I apply strategy *S1* suggested by Ayat and Burridge (2000). They suggest first estimating the following equation(s) in which t represents a time trend and y represents wages or prices:

$$\Delta y_t = (r-1)y_{t-1} + a_1 + a_2 t + a_3 t^2 + \sum_{j=1}^{s} a_j \Delta y_{t-j} + e_t \qquad (9)$$

These results are presented in table 7. These results suggest that the null of a unit root is rejected. Given this result, Ayat and Burridge (2000) suggest next testing the significance of the coefficient on the trend terms using standard tables to evaluate the t-statistics on the a_2 terms. These results are also shown in table 6. If the unit root is rejected and the quadratic trend term is not rejected, then we stop, since this unit root test is "the only one available which is invariant to the maintained quadratic trend" (Ayat and Burridge, p. 78).

The results are methodologically significant because they suggest that including the quadratic trend is important and affects the unit root result. Specifically, without the quadratic trend (with or without the linear trend) we would mistakenly fail to reject the null hypothesis of a unit root. This example illustrates the importance of including a trend of the appropriate power.

Furthermore, the results are economically significant because they suggest that wage inequality began to decrease following NAFTA. The results also suggest that the relative price of skill-intensive goods also fell after NAFTA. The results from earlier sections suggest that in the long run, these two variables are closely related. Now that we conclude that the two series are quadratic-trend stationary, we can apply the band pass filter to gain some insight about the time frame that is relevant for the Stolper-Samuelson theorem.

To get an idea of the frequency at which prices and wages are related, we appeal to the theory of spectral analysis of time series. This theory has been applied primarily in macroeconomics to separate "short run" relationships (high frequency) from "long run" relationships (low frequency). A tool used to isolate the different frequency components in time series is the ideal band pass filter. The ideal band pass filter applies a linear transformation to a series that removes all variation except that which occurs at the frequency of interest.

Unfortunately, the ideal band pass filter requires an infinite series. Christiano and Fitzgerald (1999) present an approximation to the ideal band pass filter that uses raw data (such as that represented by a series *x* of actual length T) to isolate the frequency component *y* by estimating the *B* parameters in the following equations (equations 1.2 and 1.3 in Christiano and Fitzgerald 1999)

$$\hat{y}_t = B_0 x_t + B_1 x_{t+1} + ... + B_{T-1-t} x_{T-1} + \mathrm{B}_{T-t} x_t + B_1 x_{t-1} + ... + B_{t-2} x_2 + \mathrm{B}_{t-1} x_1 \qquad (10)$$

in which[19]

$$\begin{aligned} B_j &= \frac{\sin(jb) - \sin(ja)}{p\, j};\ j \geq 1 \\ B_0 &= \frac{b-a}{p};\ a = \frac{2p}{p_u};\ b = \frac{2p}{p_l} \end{aligned} \qquad . \qquad (11)$$

Christiano and Fitzgerald (1999) apply this approximation to the ideal band pass filter to various macroeconomic time series to illustrate whether series are related in the short or long term. In a similar vein, I apply this approximation to the ideal band pass filter to gain insight into the timeframe in which relative prices and relative wages are related. I use the band pass filter to isolate the components of relative wages and relative prices that occur at 6-12 months, 1-3 years, and 3-5 years. I compare these results with the quadratic trends estimated over the whole sample.

The quadratic-detrended series are shown in figure 7A. As expected, the series show no clear trend. The series also show no clear relationship for month-to-month changes. This is not surprising. As Magee (1980) suggested, the Stolper-Samuelson theorem probably does not hold in the short run. Since the Stolper-Samuelson theorem assumes that adjustment costs are zero, it is essentially a "long-run" theorem.

Figures 7B and 7C show the components of relative prices and relative wages that occur at the 6-12 month frequency and the 1-3 year frequency. Again, there is no clear relationship between the series at these frequencies. To examine the relationship between the decomposed series in more detail, table 8 contains the results from a regression of relative wages on relative prices. Columns

1-3 show that at the monthly and 6-12 month frequencies, there is no statistically significant relationship between the two series. At the 1-3 year frequency, the relationship between the two series is negative and significant - a result that is consistent with significant adjustment costs in the labor market[20] and the surprising two-stage mandated wage equation results from the post-NAFTA period. Even though the coefficient on relative prices is significant, the adjusted R^2 is less than 0.05.

Figure 7D shows the 3-5 year component of the two series. The series move closely together. Relative wages are more volatile than relative prices. This is consistent with the Jones (1965) Magnification Effect: the change in relative wages is greater than the change in relative prices. The closeness of the two series also emerges in table 8. In contrast to the short-run frequencies, prices and wages are significantly positively related. The coefficient of 1.15 on relative prices is also consistent with the Jones (1965) result. Relative prices also explain a great deal of the movement in relative wages, as suggested by the adjusted R^2 of over 0.65.

To explore robustness, alternative frequencies were also examined, such as 2-4 years. Frequencies below the 3-5 year range do not generate any significant positive relationship. Another alternative is to consider two periods – a “short” run of 1-3 years and a “long” run of greater than 3 years. Subtracting the “short” run variation from the original detrended series generates the “long” run series. This division generates results shown in figures 8a and 8b. As in the earlier figures, the “short” run graphs generate no clear relationship between prices and wages. The “long” run series, however, exhibit a much closer relationship. These results suggest that the 3-5 year frequency is a lower bound to the time frame in which the price and wage relationship emerges in Mexico. Figure 9 shows the quadratic trends of each series over the whole sample. The adjusted R^2 in the regression of the quadratic trend of wages on the quadratic trend of prices is over 0.90. These results suggest that the relationship between relative prices and relative wages first emerges over the 3-5 year period and grows over time.

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[19] The B_{T-t} and B_{T-1} are linear functions of the other B_j terms, as described by Christiano and Fitzgerald (1999).

[20] Heckman and Páges (2000) find significant effects of job security regulations that affect employers’ ability to adjust employment. Their analysis, however, does not include Mexico.

IV. Conclusions

One area of debate in the trade and wages literature is whether changes in product prices can explain changes in wage inequality as trade theory predicts. Mexico, a small, recently liberalized economy, offers two different policy changes. First, Mexico liberalized trade with an arguably less-skill abundant world when it joined the GATT in 1986 (Wood 1997). Prior to GATT, Mexico protected less-skill intensive industries. Following entrance to the GATT, the relative price of skill-intensive goods rose and, consistent with the predictions of the Stolper-Samuelson theorem, the relative wage of skilled workers rose. Second, when Mexico further liberalized trade with Canada and the United States, two nations that are skill abundant relative to Mexico, the relative price of skill-intensive goods fell. Again consistent with the predictions of the Stolper-Samuelson theorem, the relative wage of skilled workers fell after NAFTA.

To examine the link between changes in relative prices and changes in relative wages, this paper applies two techniques found in the literature and adds a new time-series approach. All three techniques generate consistent results that suggest that changes in relative prices and changes in relative wages are related. The third approach, the band pass filter, provides some of the first evidence about the timing of the Stolper-Samuelson effects. The band pass filter results suggest that the relationship between prices and wages begins to emerge in the 3-5 year range and grows stronger over time.

Appendix A: Construction of the Price Data

The product-level price data used in this study are from the Mexican *Instituto Nacional de Estadistica, Geographia, e Informatica (INEGI).* There are, on average, 25 products per 4-digit industry for a total of 947 products. The price data are computed as unit values from value and volume data and then aggregated into averages across 4-digit industries. For each industry I constructed both the Laspeyeres (base-year quantities) and Paasche (current quantities) price indices. There are relatively few differences between the two measures. For the empirical work in this paper I used the arithmetic average of the two indices.

One issue that arose with the construction of the price indices is that quantities for some products were not available. As a result, unit values and price indices could not be computed over all available products in the industry. In most cases the share of the excluded products in the total industry value is relatively small. For industries missing quantities for certain goods, I constructed the price indices from available unit prices. I dropped industries with no price information.

INEGI constructs and publishes price indices for the two-digit industry level. To test for robustness, I also used these measures in place of the 4-digit constructed price indices. The results are qualitatively similar but, as expected, the two-digit price indices exhibit much smaller variance.

Appendix B: ISIC Rev. 2 Codes

ISICRev2	Description
3111	Slaughtering, preparing and preserving meat
3112	Manufacture of dairy products
3113	Canning and preserving of fruits and vegetables
3114	Canning, preserving and processing of fish, crustacea and similar foods
3115	Manufacture of vegetable and animal oils and fats
3116	Grain mill products
3117	Manufacture of bakery products
3118	Sugar factories and refineries
3119	Manufacture of cocoa, chocolate and sugar confectionery
3121	Manufacture of food products not elsewhere classified
3122	Manufacture of prepared animal feeds
3131	Distilling, rectifying and blending spirits
3132	Wine industries
3133	Malt liquors and malt
3134	Soft drinks and carbonated waters industries
3140	Tobacco manufactures
3211	Spinning, weaving and finishing textiles
3212	Manufacture of made-up textile goods except wearing apparel
3213	Knitting mills
3214	Manufacture of carpets and rugs
3215	Cordage, rope and twine industries
3219	Manufacture of textiles not elsewhere classified
3220	Manufacture of wearing apparel, except footwear
3231	Tanneries and leather finishing
3232	Fur dressing and dyeing industries
3233	Manufacture of products of leather and leather substitutes, except footwear and wearing apparel
3240	Manufacture of footwear, except vulcanized or moulded rubber or plastic footwear
3311	Sawmills, planing and other wood mills
3312	Manufacture of wooden and cane containers and small cane ware
3319	Manufacture of wood and cork products not elsewhere classified
3320	Manufacture of furniture and fixtures, except primarily of metal
3411	Manufacture of pulp, paper and paperboard
3412	Manufacture of containers and boxes of paper and paperboard
3419	Manufacture of pulp, paper and paperboard articles not elsewhere classified
3420	Printing, publishing and allied industries
3511	Manufacture of basic industrial chemicals except fertilizers
3512	Manufacture of fertilizers and pesticides
3513	Manufacture of synthetic resins, plastic materials and man-made fibres except glass
3521	Manufacture of paints, varnishes and lacquers
3522	Manufacture of drugs and medicines
3523	Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations
3529	Manufacture of chemical products not elsewhere classified
3530	Petroleum refineries
3540	Manufacture of miscellaneous products of petroleum and coal
3551	Tyre and tube industries
3559	Manufacture of rubber products not elsewhere classified
3560	Manufacture of plastic products not elsewhere classified
3610	Manufacture of pottery, china and earthenware
3620	Manufacture of glass and glass products
3691	Manufacture of structural clay products
3692	Manufacture of cement, lime and plaster
3699	Manufacture of non-metallic mineral products not elsewhere classified
3710	Iron and steel basic industries
3720	Non-ferrous metal basic industries
3811	Manufacture of cutlery, hand tools and general hardware

Appendix B: ISIC Rev. 2 Codes (continued)

ISICRev2	Description
3812	Manufacture of furniture and fixtures primarily of metal
3813	Manufacture of structural metal products
3819	Manufacture of fabricated metal products except machinery and equipment n.e.c.
3820	Manufacture of engines and turbines
3822	Manufacture of agricultural machinery and equipment
3823	Manufacture of metal and woodworking machinery
3824	Manufacture of special industrial mach. and equip. except metal and - woodworking mach.
3825	Manufacture of office, computing and accounting machinery
3829	Machinery and equipment except electrical not elsewhere classified
3831	Manufacture of electrical industrial machinery and apparatus
3832	Manufacture of radio, television and communication equipment and apparatus
3833	Manufacture of electrical appliances and housewares
3839	Manufacture of electrical apparatus and supplies not elsewhere classified
3841	Shipbuilding and repairing
3842	Manufacture of railroad equipment
3843	Manufacture of motor vehicles
3844	Manufacture of motorcycles and bicycles
3845	Manufacture of aircraft
3849	Manufacture of transport equipment not elsewhere classified
3851	Manufacture of professional and scientific, and measuring and controlling equipment, n.e.c.
3852	Manufacture of photographic and optical goods
3853	Manufacture of watches and clocks
3901	Manufacture of jewelry and related articles
3902	Manufacture of musical instruments
3903	Manufacture of sporting and athletic goods
3909	Manufacturing industries not elsewhere classified

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Figure 1a: Relative Wage of Nonproduction Workers 1986-1999

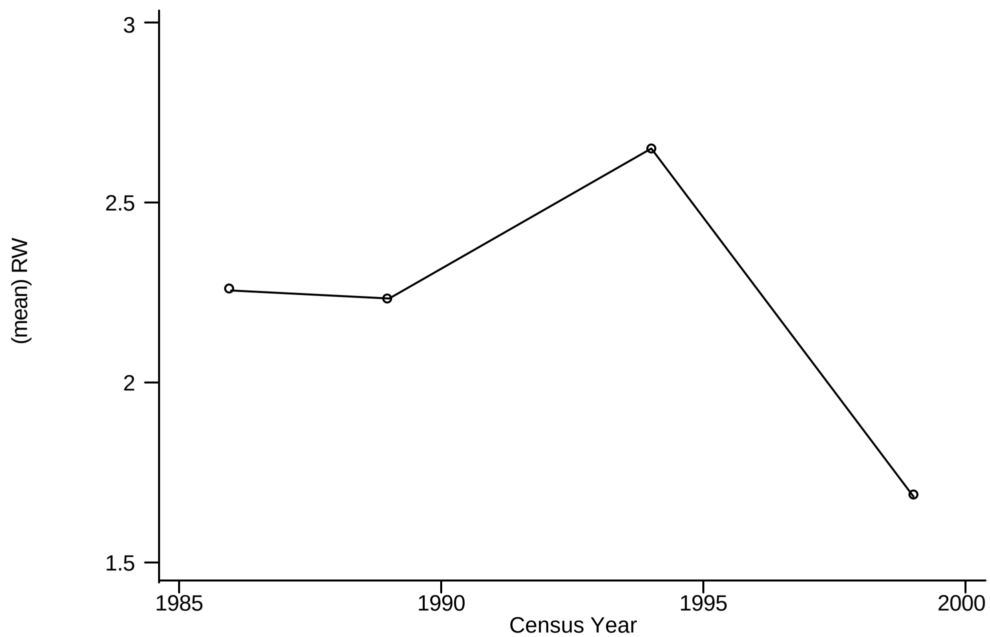
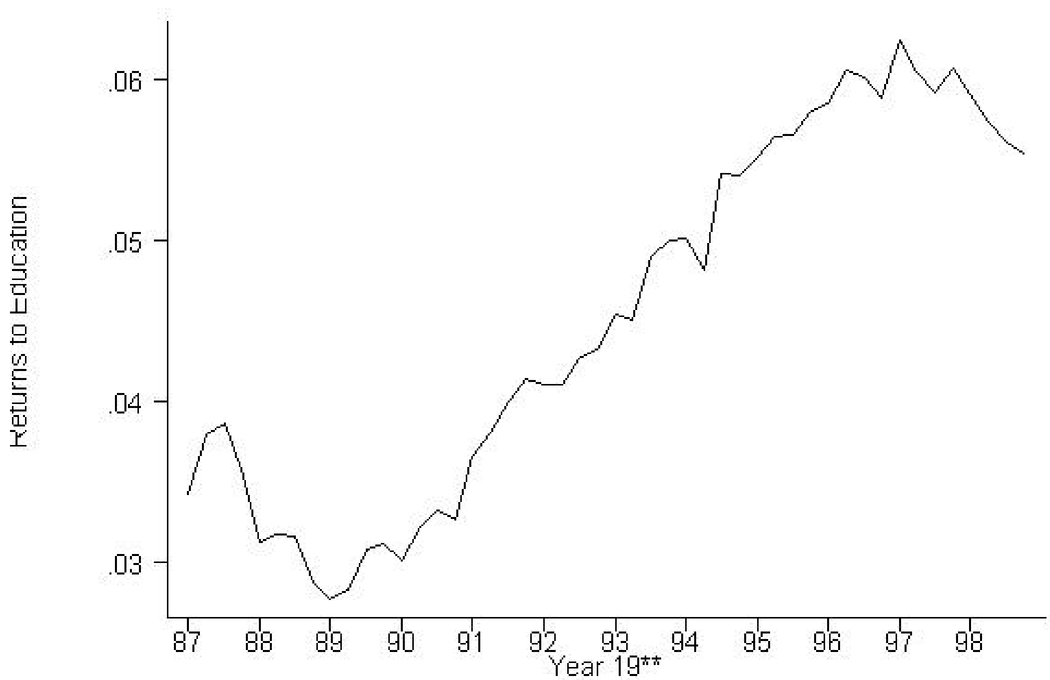


Figure 1b: Returns to Education in Mexico: 1987-1999



Notes: Estimated coefficients from a continuous education variable from a log-wage equation using pooled household-level data. Data are from the quarterly *Encuesta Nacional de Empleo Urbano* (National Urban Employment Survey) for eight cities (Tijuana, Ciudad Juarez, Matamoros, Nuevo Laredo, Monterrey, Guadalajara, Mexico State, and Mexico City) .

Figure 2a: Returns to Education in US-Mexico Border Region: 1987-1999

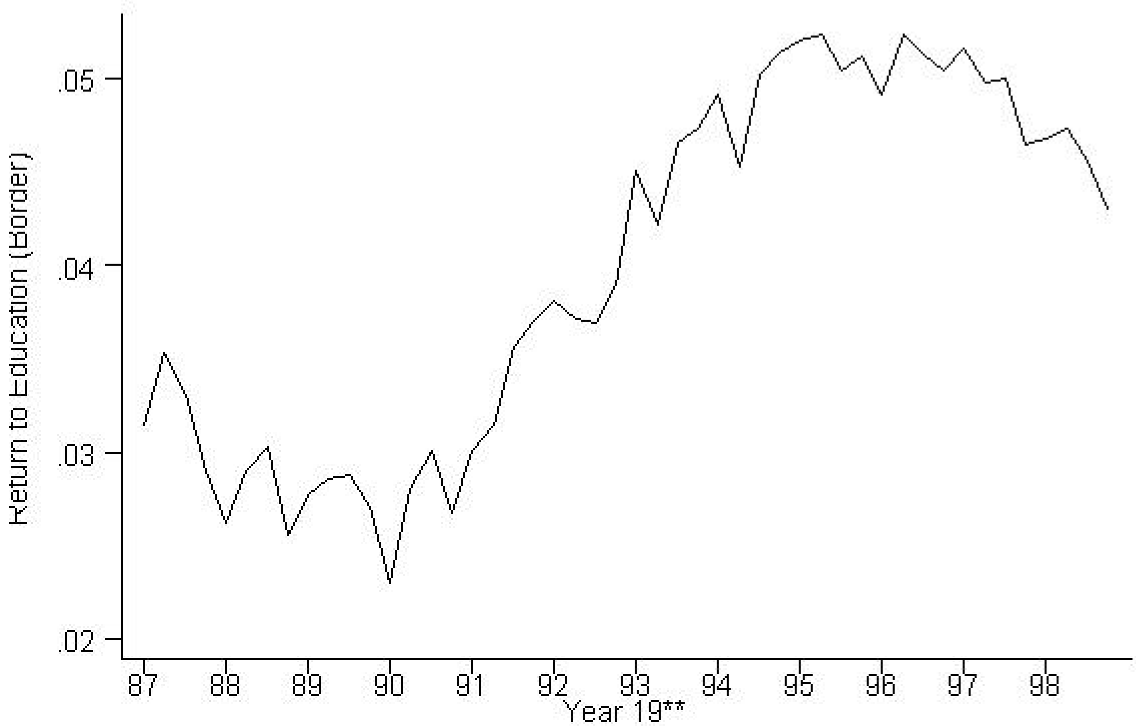
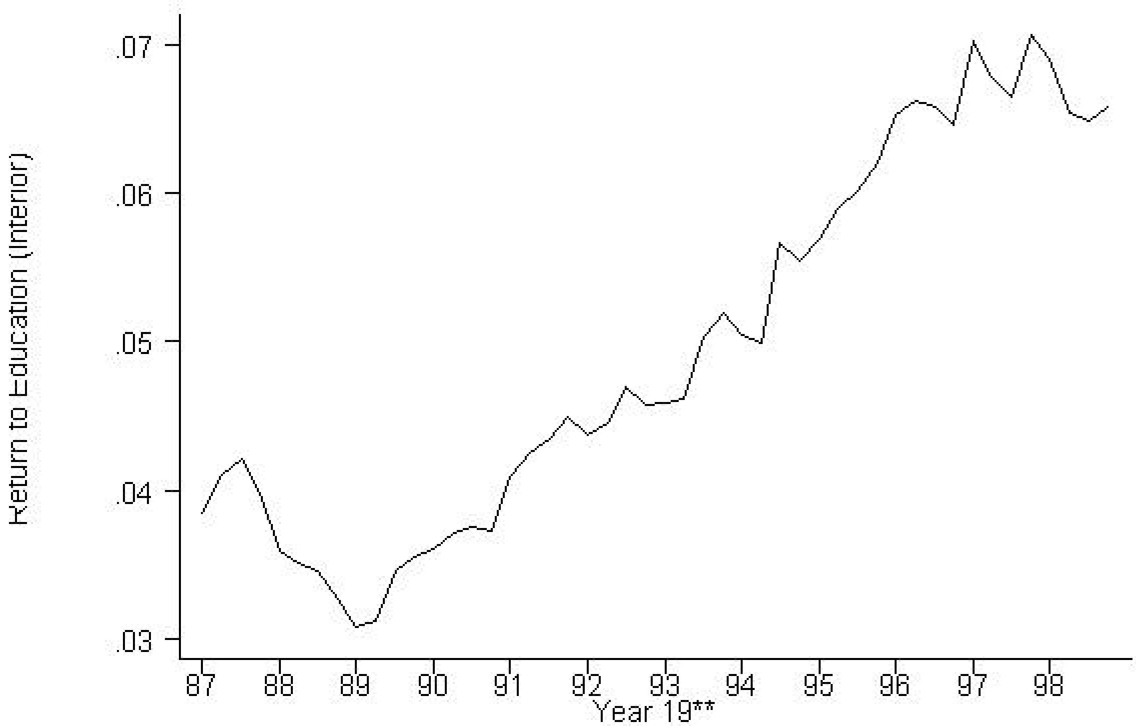


Figure 2b: Returns to Education in Mexican Interior Region: 1987-1999

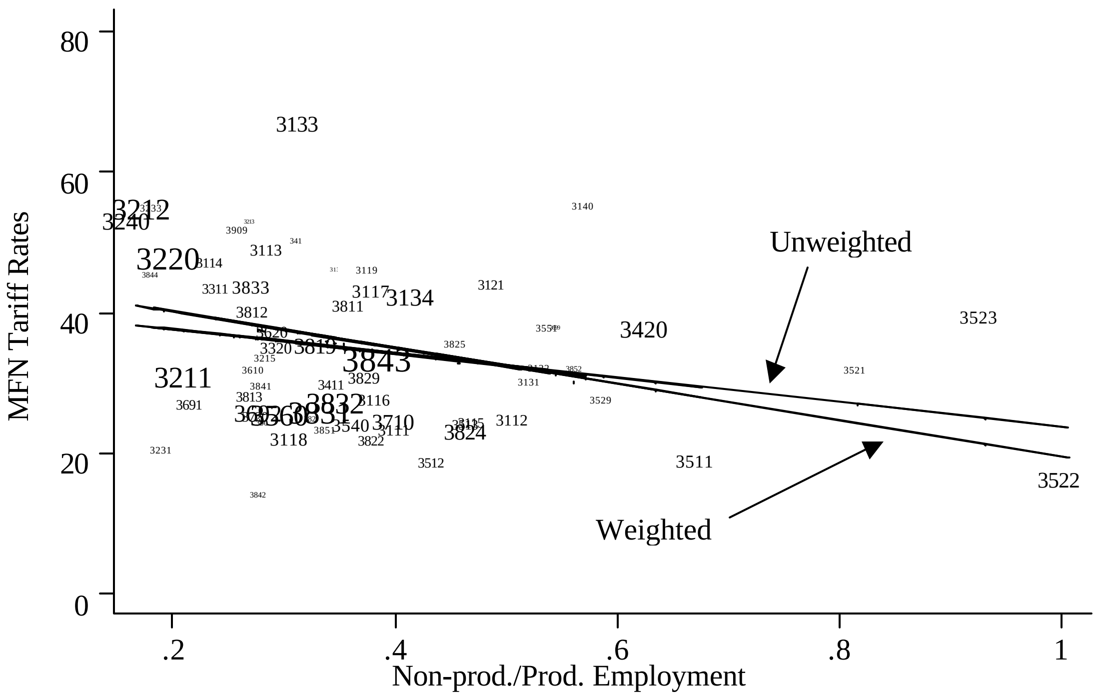


Notes: Estimated coefficients from a continuous education variable from a log-wage equation using pooled household-level data. Data are from the quarterly *Encuesta Nacional de Empleo Urbano* (National Urban Employment Survey). Border cities include Tijuana, Ciudad Juarez, Matamoros, and Nuevo Laredo. Interior cities include Monterrey, Guadalajara, Mexico State, and Mexico City.

Figure 3: Relative Price and Wage Movements in Mexico, 1987-1999

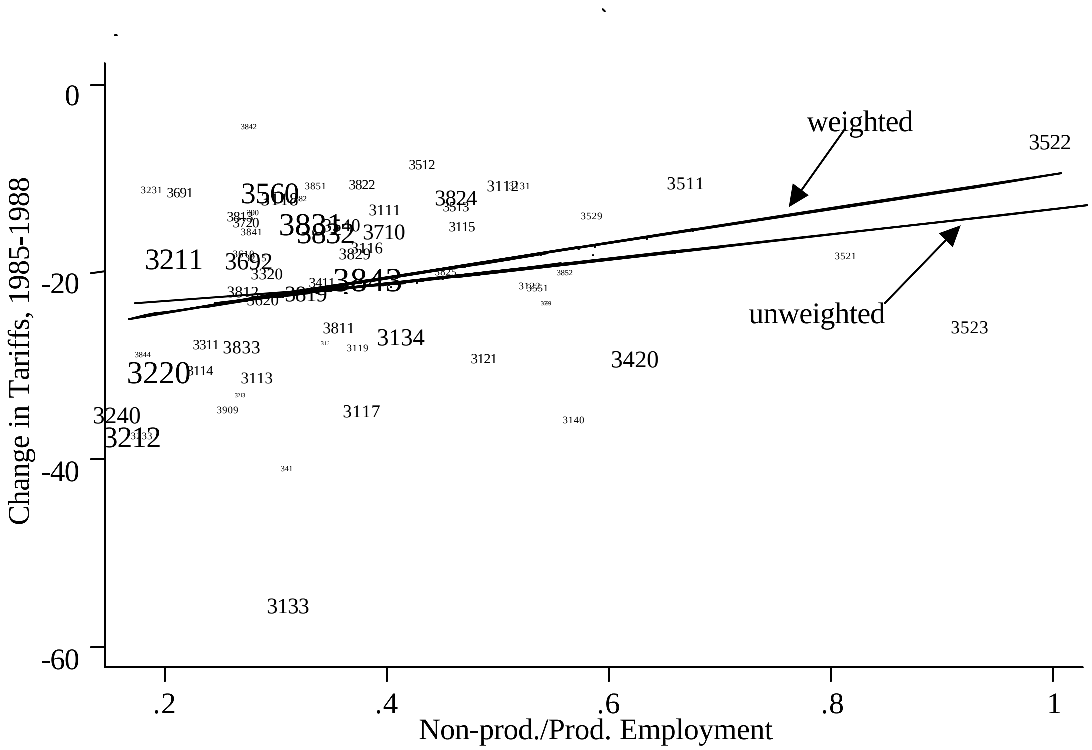
Notes: For both series, "relative" implies the non-production/production worker ratio. Data are from the Monthly Industrial Survey, which cover manufacturing as described in the text.

Figure 4: Average Tariff Levels and Relative Employment: 1985



Notes: The graph plot points are the ISIC Rev. 2 Industry Codes. Relative size reflects total industry employment. Employment data are from the 1985 Mexican Industrial Census.

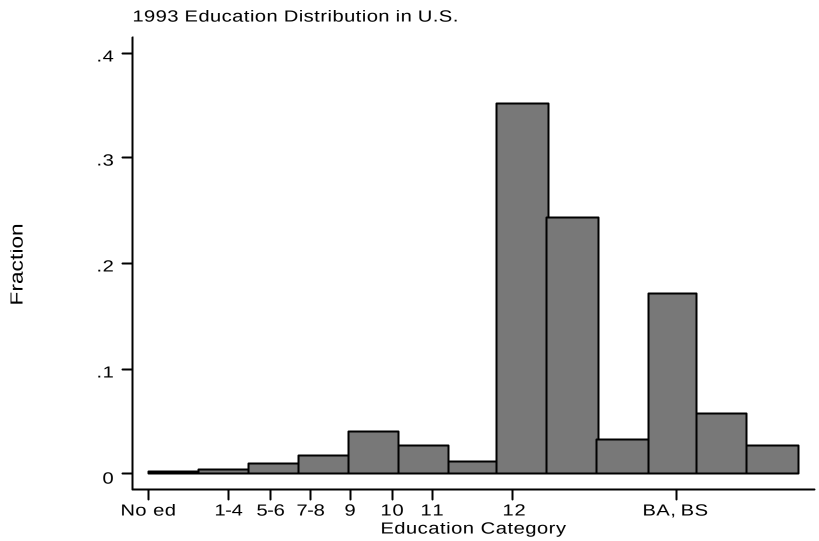
Figure 5: Tariff Changes and Relative Employment: 1985-1988



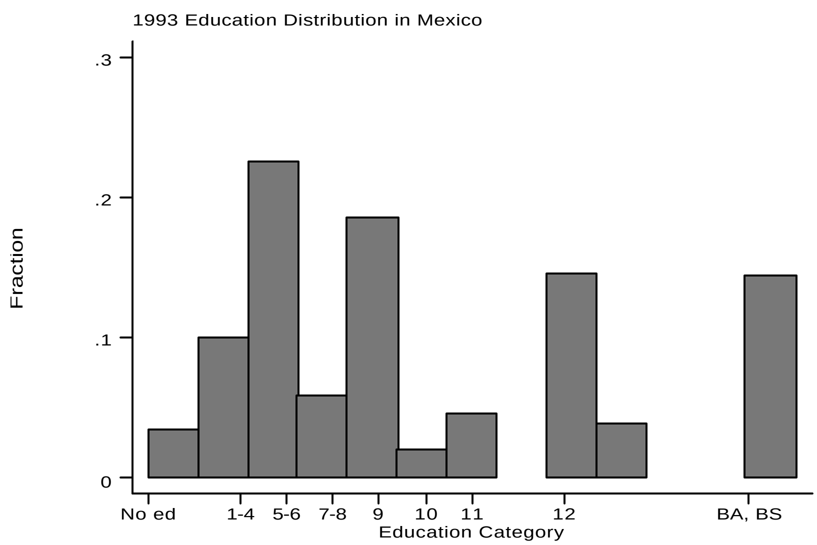
Notes: The graph plot points are the ISIC Rev. 2 Industry Codes. Relative size reflects total industry employment. Employment data are from the 1985 Mexican Industrial Census.

Figure 6: Distribution of Education in Mexico and the United States

A. United States

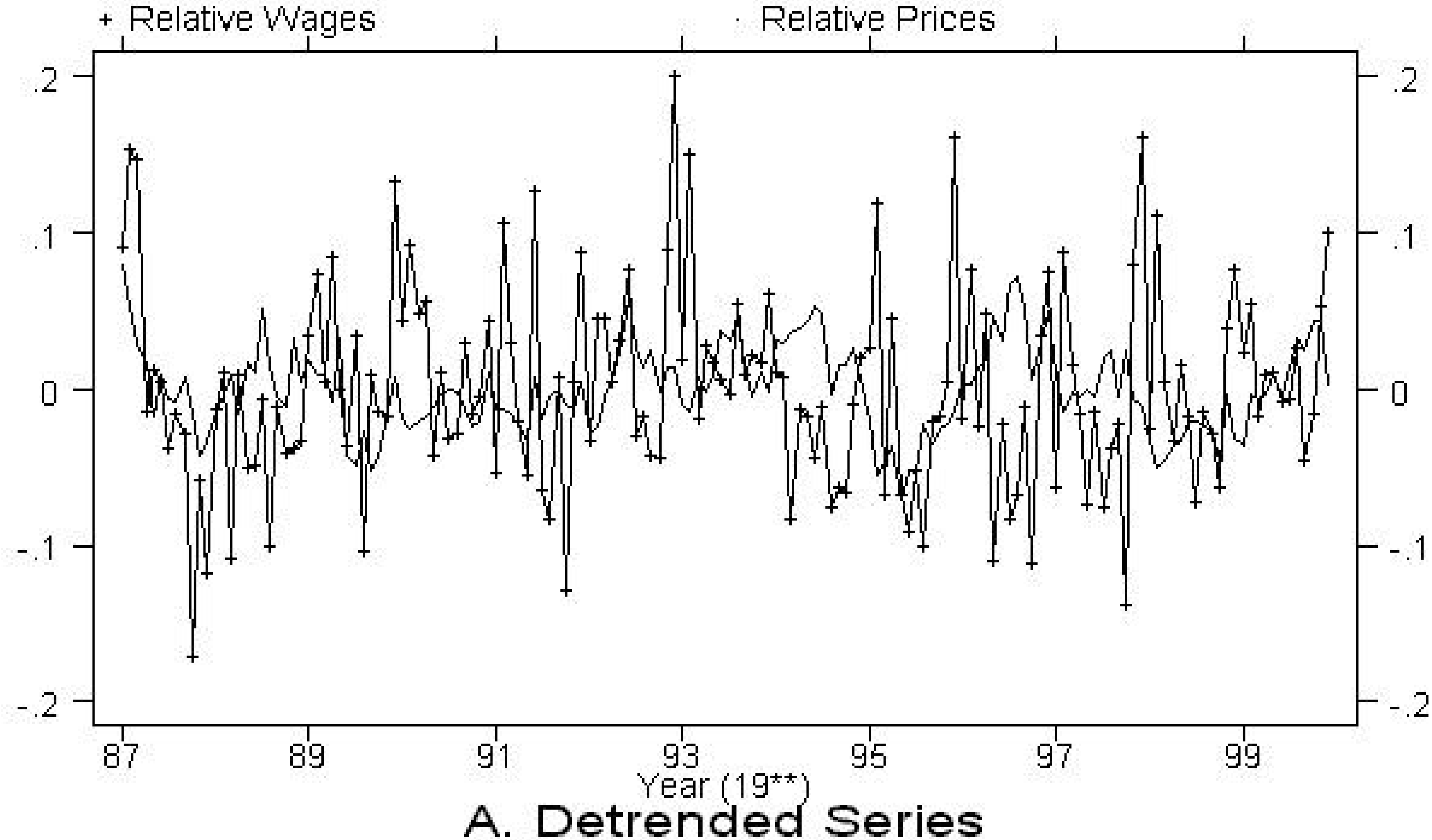


B. Mexico



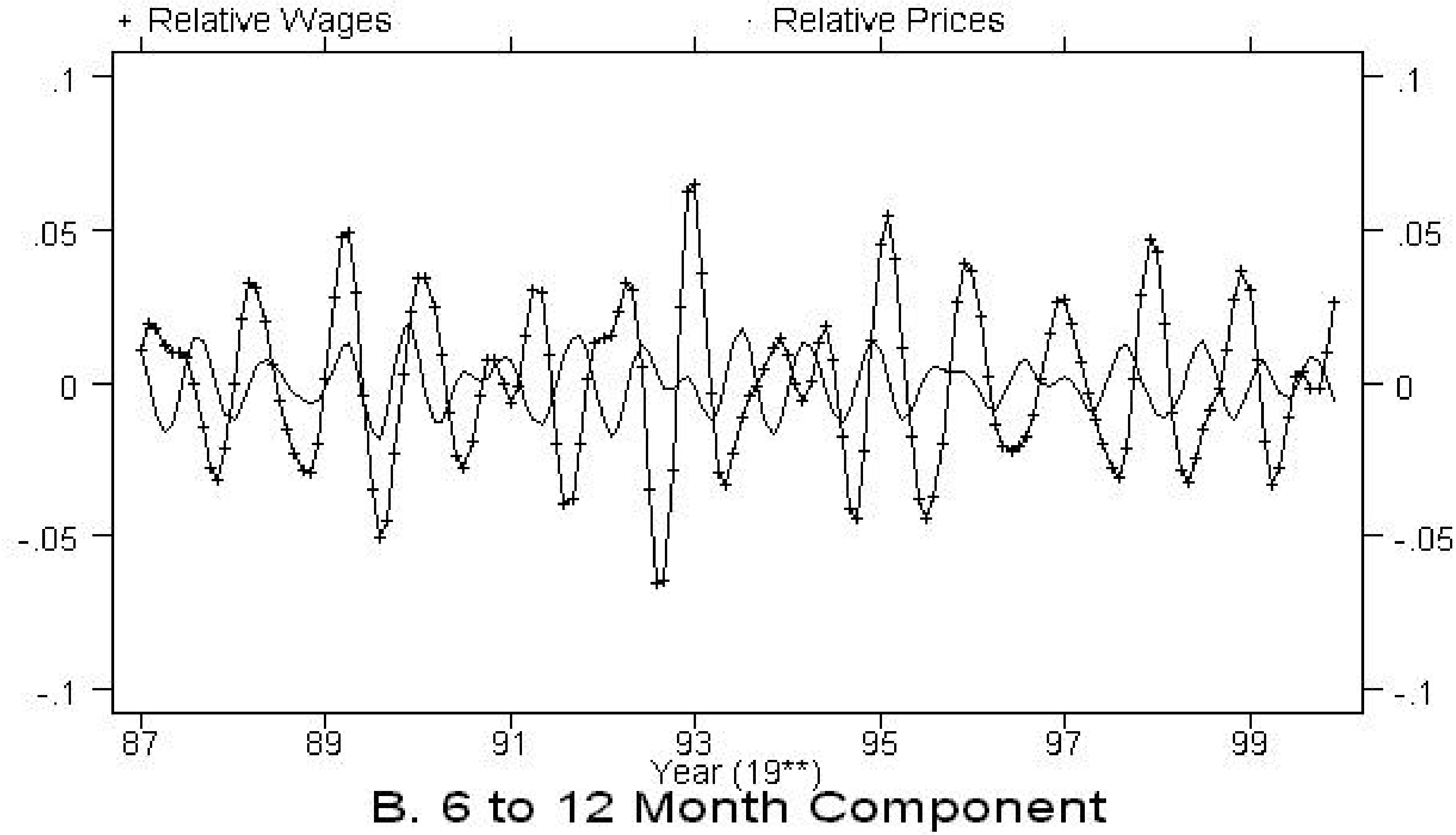
Notes: United States data are from the Monthly Outgoing Rotation Groups of the Current Population Surveys for the entire sample in 1993 (aggregated across geography and months). Mexican data are from the quarterly *Encuesta Nacional de Empleo Urbano* (National Urban Employment Survey) for eight cities (Tijuana, Ciudad Juarez, Matamoros, Nuevo Laredo, Monterrey, Guadalajara, Mexico State, and Mexico City) in 1993.

Figure 7A: Relative Price and Wage Movements in Mexico, 1987-1999
Band Pass Filter Results



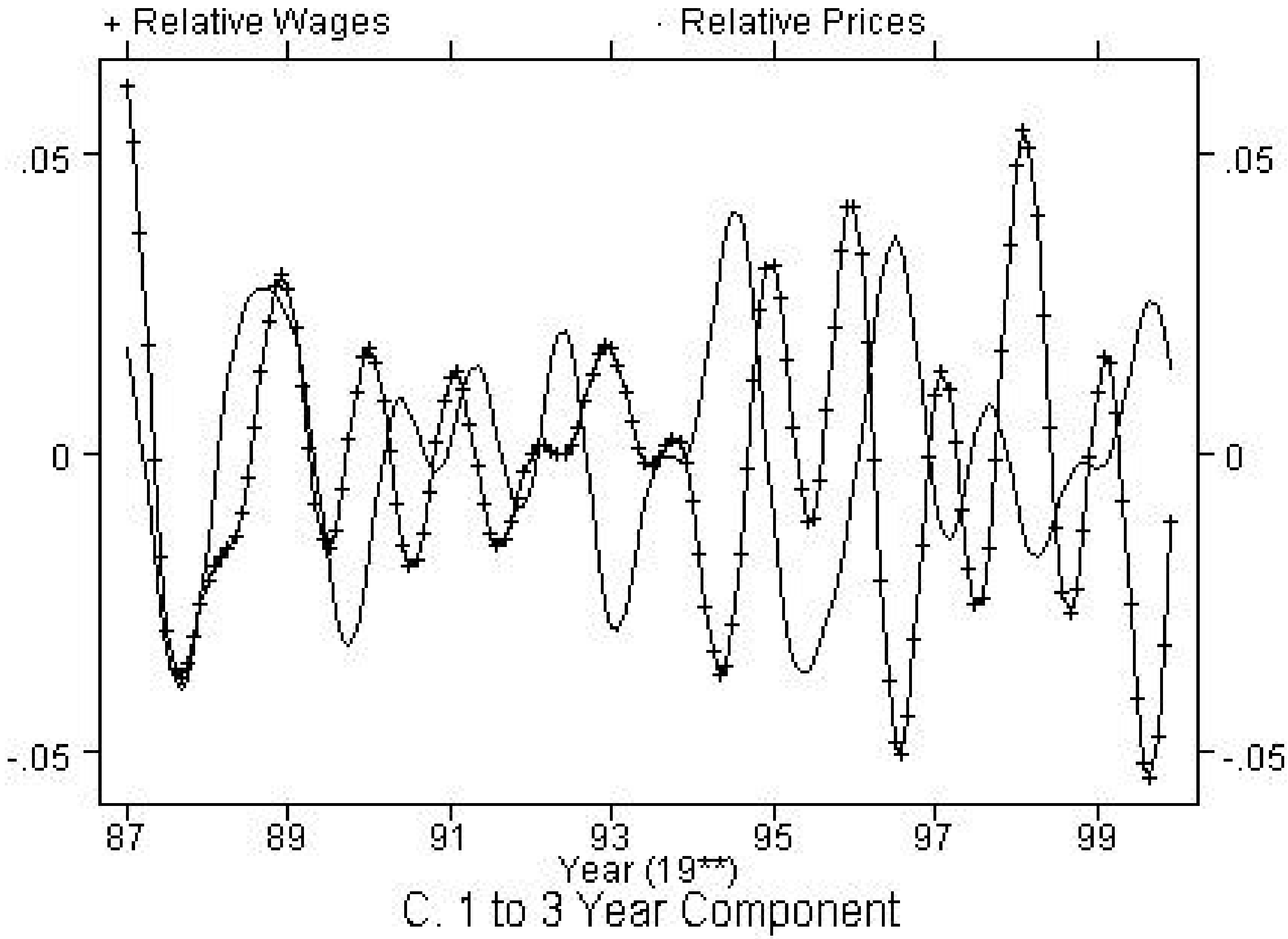
Notes: For both series, "relative" implies the non-production/production worker ratio. Data are from the Monthly Industrial Survey, which cover manufacturing as described in the text.

Figure 7B: Relative Price and Wage Movements in Mexico, 1987-1999
Band Pass Filter Results



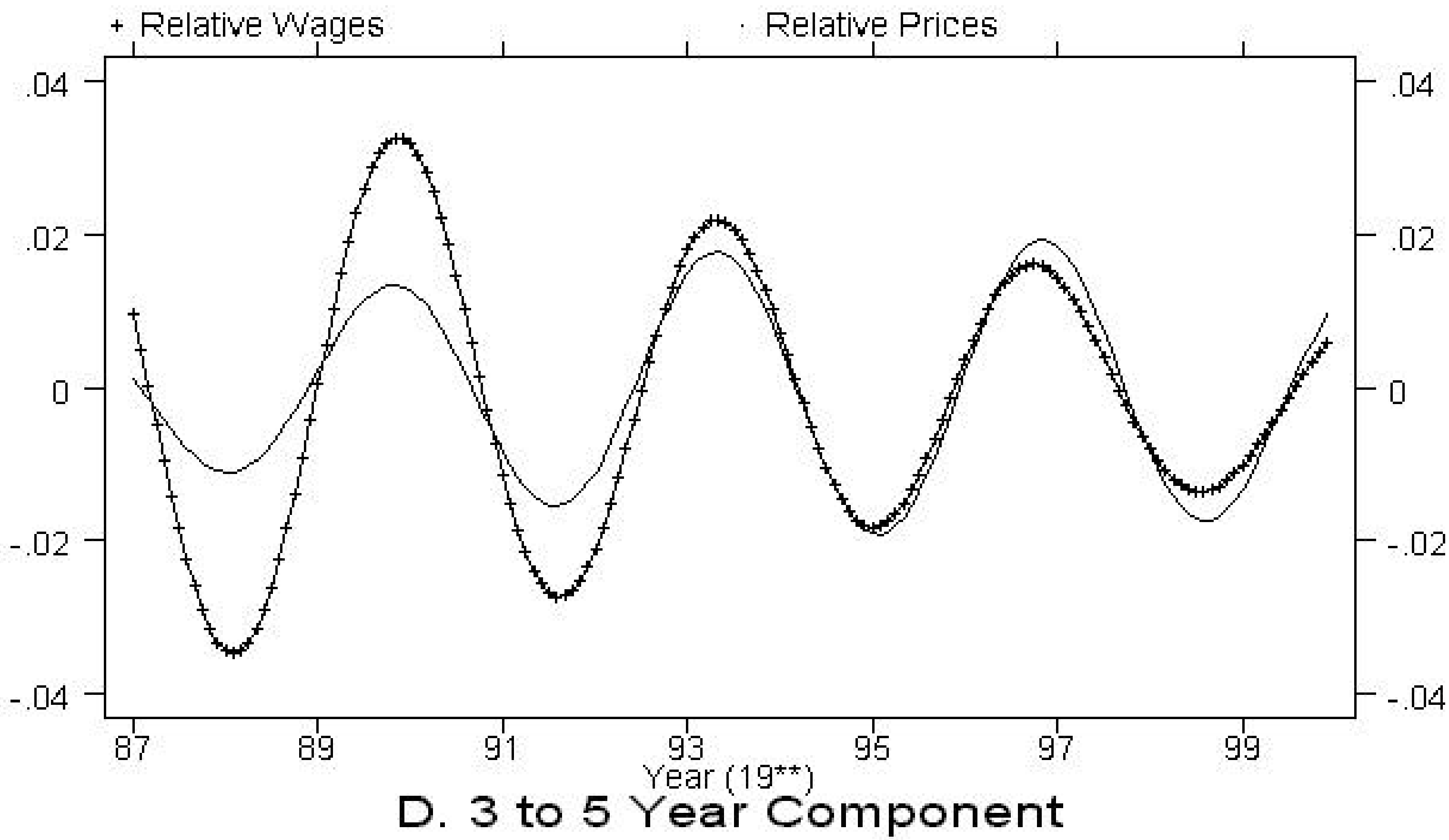
Notes: For both series, "relative" implies the non-production/production worker ratio. Data are from the Monthly Industrial Survey, which cover manufacturing as described in the text.

Figure 7C: Relative Price and Wage Movements in Mexico, 1987-1999, Band Pass Filter Results



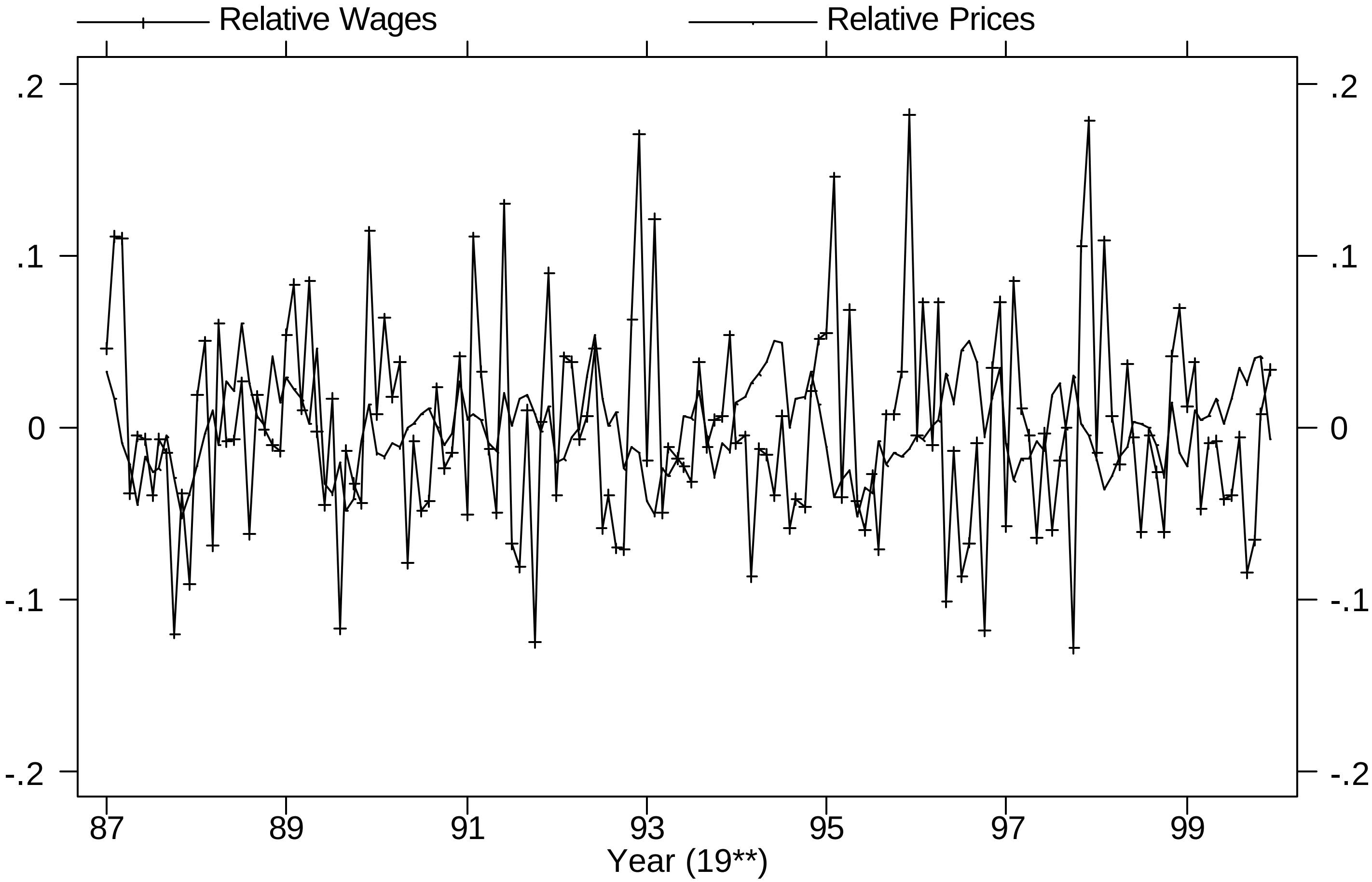
Notes: For both series, "relative" implies the non-production/production worker ratio. Data are from the Monthly Industrial Survey, which cover manufacturing as described in the text.

Figure 7D: Relative Price and Wage Movements in Mexico, 1987-1999
Band Pass Filter Results



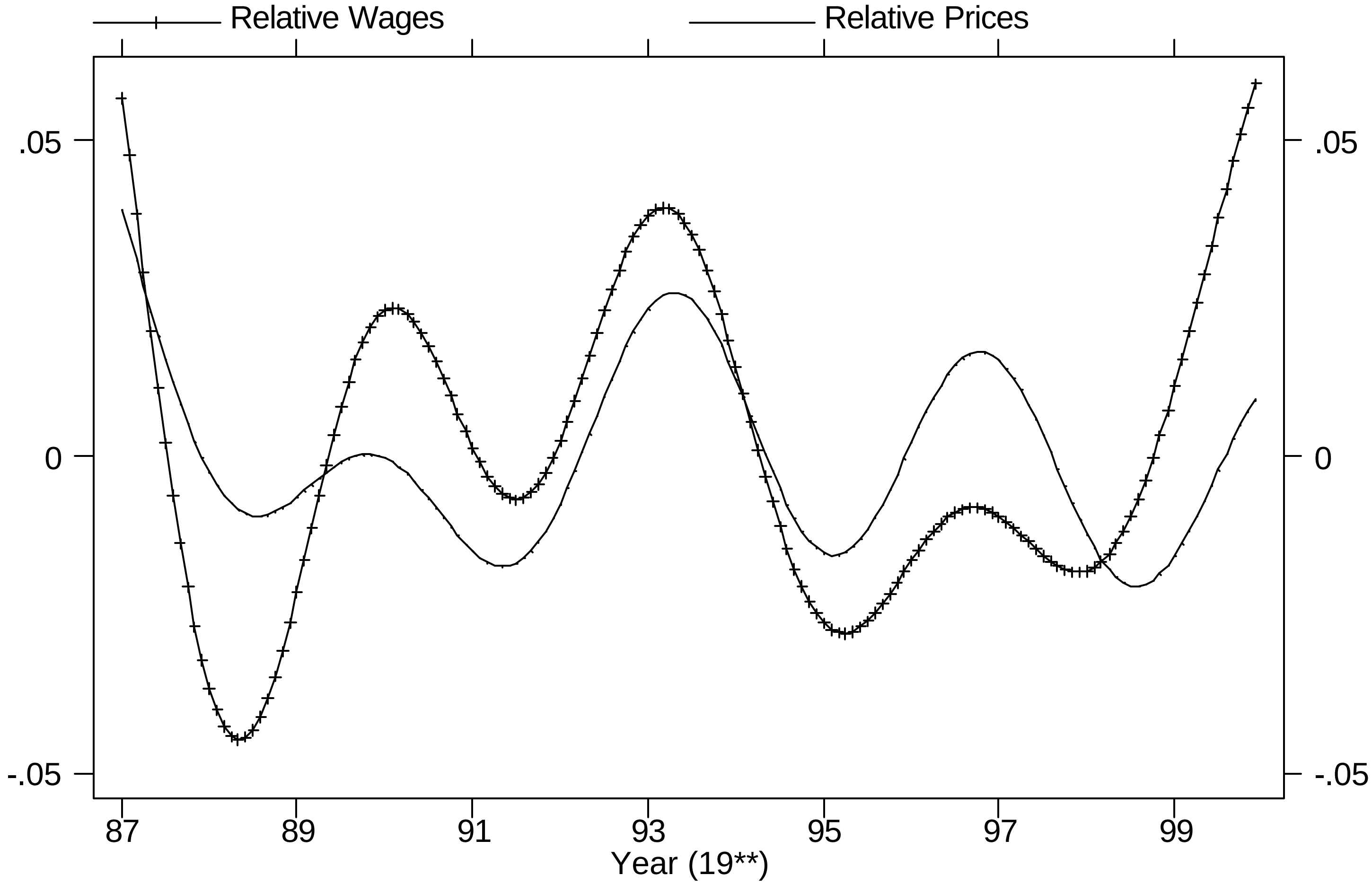
Notes: For both series, "relative" implies the non-production/production worker ratio. Data are from the Monthly Industrial Survey, which cover manufacturing as described in the text.

Figure 8a: Relative Price and Wage Movements in Mexico, 1987-1999
Band Pass Filter Results



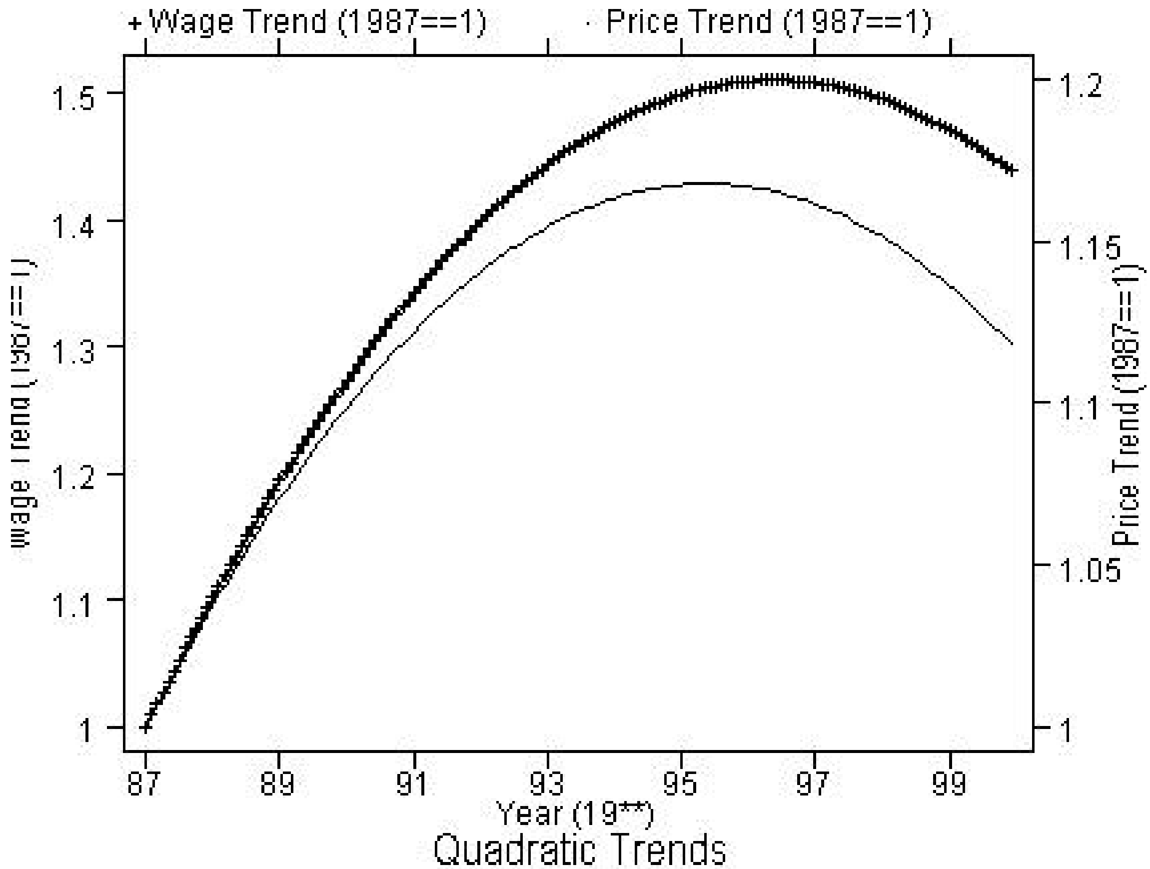
A. 2 to 36 Month Component

Figure 8b: Relative Price and Wage Movements in Mexico, 1987-1999
Band Pass Filter Results



B. >36 Month Component

Figure 9: Quadratic Trends in Prices and Wages



Notes: For both series, "relative" implies the non-production/production worker ratio. Data are from the Monthly Industrial Survey, which cover manufacturing as described in the text.

Table 1: Summary Statistics of the Mexican Monthly Industrial Survey

Industry	Sales	Employment	Average Wage (dollars per hour) H	Average Wage (dollars per hour) L	H/L	Average Education (years) Overall	Average Education (years) H	Average Education (years) L
Food	45,933.4	182,370.2	4.62	1.54	0.584	8.78	11.72	7.30
Textiles	8,218.5	108,615.4	2.98	1.36	0.323	7.92	10.96	7.28
Wood	966.4	11,389.8	2.84	1.12	0.325	7.97	11.76	7.23
Paper	9,068.5	41,139.8	4.34	1.46	0.383	8.69	11.56	7.75
Chem.	42,270.0	166,318.8	4.97	1.96	0.797	9.86	12.35	8.08
Glass	11,961.2	57,463.6	5.16	1.55	0.420	7.96	12.09	7.02
Metals	24,681.0	57,677.1	4.79	1.77	0.440	8.87	11.75	7.76
Mach.	62,851.0	268,148.3	4.54	1.62	0.512	8.91	11.92	8.07
Other	749.0	7,632.9	4.07	1.33	0.399	8.04	11.07	7.42
Mean	37,547.8	164,793.4	4.40	1.61	0.525	8.76	11.81	7.67

Notes: Food represents the food and beverage industry. Textiles includes leather products and apparel. Paper includes printing. Glass represents all non-metallic minerals (e.g. stone and clay). Metals represents basic metals. "Mach" represents Metal Products, Machinery, and Equipment, including automobiles. The first five columns of data are from the Mexican Monthly Industrial Census. The last three columns of data are from the Mexican National Survey of Urban Employment. Sales and employment figures are the averages over time of the sums across four-digit industries within each two-digit industry. Sales figures are in thousands of new pesos. H represents non-production workers, and L represents production workers. H/L is the ratio of the number of non-production workers to the number of production workers. Average wages exclude benefits, which are not available by worker type.

Table 2: NAFTA Tariff Changes and Factor Intensity

A. All NAFTA Products within EIM Industries

	Ordered Logit		Ordered Probit	
	Tariff Code	Time-to-Zero	Tariff Code	Time-to-Zero
Nonproduction Cost Share	-0.982	-1.169	-2.290	-3.575
	(0.310)**	(0.361)**	(0.567)**	(0.863)**
Production Cost Share	0.137	-0.148	0.540	0.889
	(0.453)	(0.478)	(0.753)	(0.825)
Observations	5981	5981	5981	5981

B. EIM Products with NAFTA Tariff Codes

	Ordered Logit		Ordered Probit	
	Tariff Code	Time-to-Zero	Tariff Code	Time-to-Zero
Nonproduction Cost Share	-3.236	-1.698	-3.770**	-1.701
	(2.272)	(2.214)	(1.256)	(1.278)
Production Cost Share	-5.979**	-6.995**	-2.180*	-3.688**
	(2.039)	(2.050)	(1.216)	(1.241)
Observations	879	879	879	879

Notes: Standard errors in parentheses. * significant at 10% level; ** significant at 5% level. The Tariff Code has six values in increasing order of protection as described in the text. The Time-to-Zero variable is the length of time until the tariff is reduced to zero, as specified in the NAFTA. In part A, the employment cost shares (remunerations/value of production) for each industry in the EIM were assigned to all products within that industry specified in the NAFTA tariff codes. In part B, the products found in the EIM were matched with their NAFTA tariff code and weighted by industry employment.

Table 3: Price Changes and Initial Skill Intensities

	(1) 87-93	(2) 88-93	(3) 93-97	(4) 93-98
H/L 87	0.144			
	(0.065)**			
H/L 88		0.168		
		(0.088)*		
H/L 93			-0.118	-0.148
			(0.086)	(0.084)*
Constant	-0.373	-0.328	-0.005	-0.023
	(0.042)**	(0.055)**	(0.057)	(0.054)
Observations	123	123	123	123
Adj R-squared	0.031	0.016	0.007	0.017

Notes: H represents non-production workers. L represents production workers. Standard errors are in parentheses. ** significant at 5% level; * significant at 10% level. Regressions are weighted by mean value of production.

Table 4: Mandated Wage Equation Results

$$\hat{p}_j = a + \sum_i \hat{w}_i q_{ij} + e_j$$

		Change in Prices over period: 87-93	88-93	93-98	96-99
production workers	predicted	-1.062	-1.189	-0.679	1.230
		(0.816)	(0.876)	(1.019)	(0.669)
	actual	0.005	0.164	-0.243	0.072
	p-value	0.193	0.125	0.670	0.086
non-production workers	predicted	2.257	2.134	-1.662	1.190
		(1.060)	(1.031)	(0.865)	(0.412)
	actual	0.583	0.548	-0.237	0.039
	p-value	0.117	0.126	0.102	0.006
	N	127	127	127	127
	Adj-R2	0.021	0.018	0.046	0.132

Notes: Value of industry production used as weights. Residual input shares (capital, land, and material) were not included in these regressions. Regressions that included residual input shares produced very similar results. Regressions without weights produced similar coefficient values but larger standard errors. Standard errors are in parentheses.

Table 5: Mandated Wage Regressions (Census Data)

	Change in Prices over period:							
	88-93	87-94	88-93	87-94	88-93	87-94	88-93	87-94
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(e) TFP					0.713	0.783	0.456	0.496
					(0.19)	(0.17)	(0.23)	(0.19)
Non-Production	-4.534	-4.374	1.538	1.126	0.76	0.271	2.056	0.956
	(2.71)	(2.64)	(1.42)	(1.35)	(1.24)	(1.10)	(1.40)	(1.26)
Production	0.516	0.382	0.181	0.084	0.168	0.07	-0.061	-0.474
	(1.29)	(1.26)	(0.91)	(0.87)	(0.79)	(0.70)	(0.89)	(0.83)
Capital	-3.385	-2.816	-0.824	-0.548	-0.805	-0.527	-0.846	-0.201
	(1.48)	(1.44)	(0.99)	(0.94)	(0.86)	(0.76)	(0.96)	(0.89)
Materials	-1.217	-1.056						
	(0.31)	(0.30)						
Constant	0.599	0.45	-0.266	-0.305	-0.246	-0.284	-0.243	-0.281
	(0.20)	(0.20)	(0.10)	(0.10)	(0.09)	(0.08)	(0.10)	(0.09)
N	43	43	43	43	43	43	43	43
Adj. R^2	0.257	0.203	-0.026	-0.049	0.24	0.324	0.045	0.095

Notes: In columns (1) and (2) the sum of factor shares is not constrained. In columns (3) and (4) factor shares are constrained to sum to one. The dependent variable is the change in the value-added price in each period. Columns (5) and (6) include Total Factor Productivity (TFP) calculated as the difference between the change in inputs and the change in output. Columns (7) and (8) include TFP adjusted by changes in inter-industry wage differentials (eTFP). Factor shares are constrained to sum to one in regressions (5)-(8). The dependent variable is the change in the value-added price in each period. Standard errors are in parentheses.

Table 6: Predicted Effects of Tariffs on Wages

	(1) 87-88	(2) 88-93	(3) 94:1-94:11	(4) 94-99
Production Cost Share	-0.090	-0.091	-0.096	-0.0032
	(0.030)	(0.031)	(0.026)	(0.0008)
Nonproduction Cost Share	0.173	0.176	-0.005	-0.0002
	(0.057)	(0.058)	(0.027)	(0.0009)
Constant	-0.330	-0.277	0.072	0.849
	(0.003)	(0.003)	(0.002)	(0.00008)
Observations	126	126	874	874
Adj. R-squared	0.062	0.062	0.016	0.016

Notes: Coefficients from the second stage regressions described in Feenstra and Hanson (1999). In the first stage, the change in prices over the time period noted in each column was regressed on the change in tariffs that took place following the GATT between 1985 and 1988 or were mandated by NAFTA for January 1, 1994. The predicted changes in prices from the first stage regressions were then used as the dependent variable in these regressions. Industry employment was used to weight both first and second stage regressions. Standard errors are in parentheses. For columns (1) and (2), industry-level tariffs were used. For columns (3) and (4), product-level tariffs were used.

Table 7: Unit Root Test Results

$$\Delta y_t = (r-1)y_{t-1} + a_1 + a_2 t + a_3 t^2 + \sum_{j=1}^{s} a_j \Delta y_{t-j} + e_t$$

	Prices	Prices	Prices	Wages	Wages	Wages
(r-1)	-0.089	-0.123	-0.272	-0.048	-0.058	-0.874
	(2.345)	(2.543)	(3.952)	(2.527)	(1.581)	(6.324)
a_1	0.079	0.047	-4.998	0.139	0.075	-91.699
	(2.365)	(1.102)	(2.942)	(2.713)	(0.384)	(6.073)
a_2		0.001	0.110		0.001	1.956
		(1.130)	(2.988)		(0.337)	(6.081)
a_3 (x10)			-0.001			-0.010
			(2.971)			(6.078)
a_1	-0.291	-0.240	-0.039	-0.826	-0.787	0.691
	(1.615)	(1.290)	(0.204)	(3.266)	(2.831)	(1.985)
a_2	0.003	-0.036	-0.183	0.145	0.094	-1.490
	(0.016)	(0.173)	(0.877)	(0.332)	(0.204)	(3.051)
a_3	0.055	0.066	0.106	-0.039	-0.011	0.867
	(0.671)	(0.803)	(1.307)	(0.127)	(0.034)	(2.702)
a_4				0.051	0.045	-0.150
				(0.626)	(0.537)	(1.851)
Observations	152	152	152	151	151	151
Adjusted R^2	0.098	0.100	0.145	0.404	0.400	0.520

Notes: Absolute values of t-statistics are in parentheses. The absolute value for the 5% DF test statistic is 2.89 without a trend term and 3.45 with a trend term. The absolute value for the 5% test statistic with a quadratic trend is between 3.48 and 3.61.

Table 8: Bivariate Regressions of Wages on Prices

$$\hat{w} = \Theta^{-1}\hat{p}$$

	Detrended Series	6-12 months	12-36 months	36-60 months
Θ^{-1}	0.185	-0.183	-0.245	1.146
	(1.024)	(0.738)	(2.630)	(17.859)
Adjusted R^2	0.000	-0.003	0.037	0.672
N	156	156	156	156

Notes: Absolute value of t-statistics in parentheses.