Can the Stolper-Samuelson Theorem explain relative wage movements? Evidence from Mexico

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Abstract: Rising wage inequality and increasing international trade have renewed interest in the empirical relevance of the Stolper-Samuelson theorem. Although a brilliant theoretical accomplishment, the Stolper-Samuelson theorem has received little empirical support. U.S. studies have generated mixed results partially because prices are endogenous in a large country. This paper examines the link between relative goods prices and relative wages in a small country: Mexico. This paper shows that on the eve of entering the GATT in 1986, Mexico protected less-skill-intensive industries. Trade liberalization caused dramatic movements in product prices. Starting from the initial pattern of protection, this paper then applies three approaches to comparing the relationship between product prices and relative wages against the predictions of the Stolper-Samuelson theorem. Following trade liberalization, the relative price of skill-intensive goods rose, raising the between-industry demand for skilled labor and the relative wages of skilled workers. All three approaches generate consistent empirical support for the Stolper-Samuelson theorem.

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The neoclassical Heckscher-Ohlin theorem predicts that countries will export abundant-factor-intensive goods and import scarce-factor-intensive goods. As a result, tariffs on imported goods increase returns to the scarce factor and removing tariffs should reduce the returns to the scarce factor. Industry prices link tariffs and wages in a relationship brilliantly captured in the Stolper-Samuelson theorem (1941). The Stolper-Samuelson (SS) theorem demonstrates how changes in prices, induced by changes in tariffs, alter relative factor rewards. An increase in the relative price of skill-intensive goods causes the relative returns to skill to rise, thus potentially increasing wage inequality.

Although a brilliant theoretical accomplishment, the SS theorem has received little empirical support. Magee (1980) rejects SS in favor of a specific factors model because both scarce and abundant factors tend to lobby together for industry-specific protection. More recently, a number of papers appeal to the SS theorem to explain rising U.S. wage inequality. The results of the U.S. studies have been mixed. Lawrence and Slaughter (1993) and Baldwin and Cain (1997) find little, if any, role for trade (and thus SS) in rising inequality. Alternatively, Krueger (1997), Sachs and Shatz (1994), and Schmitt and Mishel (1996) find evidence of Stolper-Samuelson effects. One reason that these studies differ is because they apply the SS theorem, which assumes a price- and technology-taking economy, to the large country (U.S.) case. In the large country case, prices are not exogenous. Although these papers incorporate the "large country" effects on prices and technology to differing degrees, a sensible alternative approach to testing the empirical relevance of the SS theorem would be to consider price movements and relative wages in a recently liberalized small country.

This paper examines the relationship between price movements and relative wages in Mexico during the GATT-NAFTA period (1985-1995). Mexico is more like the classical "small country" than the United States. Mexico's economy is about 1/17th 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 U.S. Furthermore, several changes within Mexico created an excellent environment in which to study the SS theorem. Mexico began to reduce trade barriers in 1986 when it rejected import substitution industrialization and entered the General Agreement on Tariffs and Trade (GATT). Mexico codified its commitment to trade liberalization by announcing intentions to enter into the North American Free Trade Agreement (NAFTA) in 1990. NAFTA became effective January 1 1994. Between 1985 and 1995, Mexico greatly reduced very high levels of trade protection.

As expected, trade liberalization had a dramatic and predictable effect on industry prices. Mexico protected less-skill-intensive industries before entering the GATT and tariff reductions were larger for less-skill-intensive industries. The impact on trade flows and relative wages was also dramatic. Between 1987 and 1995, the annual sum of imports and exports divided by GDP rose from 30% to 50%. Over the same period, wage inequality rose dramatically. The log-ratio of non-production/production worker wages rose 55.9%. While the pattern of protection and changes in relative wages have been shown by Revenga (1997) and Hanson and Harrison (1999), this paper is the first to document a relationship between relative product prices and relative wages consistent with the Stolper-Samuelson theorem.

To document the link between relative wages and relative prices, I rely on several sources of data. First, I combine the Industrial Survey with detailed tariff data to document the pattern of protection before liberalization according to factor intensity. To measure factor intensity, I combine Mexico's Monthly Industrial Survey with household-level survey data. This shows that the skill breakdown in the Industrial Survey (production/non-production workers) is consistent with other measures of skill (such as education). Next, I combine product-level price data with the Industrial Survey to relate changes in relative prices with changes in relative wages.

To focus on the link between prices and wages, I follow the methods pioneered in what Slaughter (1998) calls the "price studies". First, I follow Lawrence and Slaughter (1993), Krueger (1997), and Sachs and Shatz (1994). If the SS theorem can explain rising relative wages of skilled workers, then the relative price of skill-intensive goods must have risen. This "check" is a necessary condition, and I find that it is satisfied in the Mexican case. Second, following

Francois, Navia, and Nelson (1998), I test for cointegration between relative wages and relative prices. I only find weak evidence that month-to-month changes in relative wages are related to changes in relative prices. This weak finding provides a response to Slaughter's (1998) question "how fast does the SS clock tick" by suggesting slower-than-monthly adjustment. This result is also consistent with Magee (1980) who finds that the SS theorem is more appropriate for long-run adjustment. Third, I follow Baldwin and Cain (1997), Krueger (1997), Leamer (1998), Feenstra and Hanson (1999), and Haskel and Slaughter (1999) and perform "mandated wage" regressions that more closely relate to a formal derivation of the SS theorem. This approach uses factor intensities and price changes to "predict" changes in wages that are consistent with SS. This approach is problematic in U.S. studies because it assumes that prices and technology are exogenous. These problems are at least partially obviated by examining the small country case. I find that the predicted changes in wages are larger than actual changes, suggesting that SS forces were more than sufficient to cause the observed change in wages.

Given the initial levels of protection and the pattern of liberalization, the results of all three approaches provide consistent support for the SS theorem. Tariffs on less-skill-intensive goods were higher and fell more. The relative price of these goods fell, causing a between-industry shift towards skill-intensive industries. This increased the demand for skill and, in turn, the relative wage of skilled workers.

The results of this paper further suggest that what matters for the relationship between trade liberalization and wage inequality is the pattern of initial protection and not the perceived relative factor endowments. Trade liberalization may induce rising inequality in developing countries - even if they are less skill abundant - if the pattern of initial protection favored less-skill-intensive industries. The resulting price changes, as demonstrated in this paper, affect relative wages as the SS theorem predicts.

The paper unfolds in four sections. In Section I, I briefly review the formal derivation of the SS theorem. The goal of the first section is to identify conditions that guide the rest of the empirical analysis. In Section II, I describe the initial structure of protection and the pattern of liberalization, combining detailed tariff data with household and industrial surveys to classify industries and protection according to factor intensity. In Section III, I evaluate the predictions of the SS theorem described in the first section using the data described in the second section. I offer conclusions in Section IV.

I. Predictions of the Stolper-Samuelson Theorem

The Stolper-Samuelson theorem is one of the most celebrated results in trade theory, and the predictions are well known to trade theorists. Deardorff (1994) follows Jones (1964) by demonstrating the SS theorem with the following simple general equilibrium model.

Consider an economy that produces *n* goods with *m* factors. Let $\boldsymbol{w}$ be an *m*-vector of factor prices and let $\boldsymbol{p}$ be an *n*-vector of goods prices. If a_{ij} is the requirement of factor *i* to produce one unit of good *j*, then let $A(\boldsymbol{w})$ be the *m* by *n* matrix of these requirements chosen to minimize unit production costs. It is also useful to define Q as Deardorff does: the *m* by *n* matrix of factor shares in which each element

$$q_{ij} = (w_i a_{ij})/p_j. \quad (1)$$

In practice, the unit labor requirement of labor of type *i* in good *j* will be calculated as

$$a_{ij} = L_i/q_j \quad (2)$$

in which q_j is the quantity of output in industry *j*. Thus, the elements of the factor share matrix are calculated as the share of total revenues of good *j* that are paid to factor *i*.

Zero profits and perfect competition in equilibrium together imply

$$\boldsymbol{p} = \boldsymbol{w}A. \quad (3)$$

The equation that provides the basis for empirical investigations of the SS theorem is derived by totally differentiating (3) and making the necessary manipulations to generate

$$\hat{\boldsymbol{p}} = \hat{\boldsymbol{w}}\, Q \quad (4)$$

The "essential version" of the SS theorem is derived neatly when Q is square and invertable. The matrix Q is inverted to yield a direct relationship between exogenous prices and endogenous wages. However, most empirical studies use data from hundreds of industries while considering at most four factors. Since the resulting Q is not square and $n > m > 2$, the common empirical response is an 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. However, there should be a correlation between the vectors of goods price changes and factor price changes.

Whether using the Correlation Version or a more strict interpretation, the literature has identified four conditions that must hold to accredit SS forces with increasing wage inequality. First, the prices of skill intensive goods must have risen relative to the prices of less-skill intensive goods. This condition depends on the assumption of the small open economy because only in the small open economy are prices considered exogenous. The second condition is that the output shares of skill-intensive industries must have expanded. That is, in response to the change in prices there was a between-industry shift in employment towards industries that use skilled labor intensively.

The third is that the long-run relationship between relative prices and relative wages should be positive. This condition lends itself to a time-series analysis. Slaughter (1998) asks "how fast does the SS clock tick?" Applying various lag lengths to high-frequency data may generate evidence that helps answer this question. The fourth and final condition is that, for a given vector of factor shares, the wage changes predicted by the SS framework outlined above should be equal to actual wage changes. If the predicted values fall short of the actual values, then SS forces do not explain the changes in relative wages.

The papers that evaluate the price-wage relationship analyze these conditions. Early papers in the debate focus on the first and second conditions. While Lawrence and Slaughter (1993) find that relative prices of skill-intensive goods have fallen, Sachs and Shatz (1994) find that relative prices have risen. Schmitt and Mishel (1996) and Krueger (1997) support the Sachs and Shatz result. Francois, Navia, and Nelson (1998) evaluate the third condition. They argue that (4) implies that prices and wages enjoy a long-run relationship. Thus, over time, prices and wages should be cointegrated. They find evidence of a relationship between relative prices and relative wages through time.

The fourth condition has also received recent attention. 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. Leamer (1998) uses the term "mandated wage equations" to describe the empirical forms estimated with this approach. The idea behind this approach is that since the factor share matrix in (4) is not invertible, one can estimate (4) directly. The wage vector is the set of parameters that are estimated when the vector of price changes across time is regressed on the factor share matrix. The estimated vector is then compared to actual wage changes. The next two sections analyze all four conditions in the Mexican case.

II. Tariffs, Relative Prices, and Relative Wages in Mexico, 1987-1995

In this section I describe the changes in Mexico's trade policies and the changes in wage inequality that followed. Next, I describe the data used for the empirical work, describe the measures of skill, and conduct what Slaughter (1998) calls "consistency checks" for the relative price movements. This section presents two key findings: Mexico protected less-skill-intensive industries and, when protection was removed, the relative price of skill-intensive goods increased. As a result, resources shifted between industries towards those that intensively employ skilled labor.

A. The Structure of Protection in Mexico

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). When Mexico joined the GATT in 1986, it began to dramatically reduce trade barriers. Changes in tariffs and quantity restrictions between 1985 and 1990 are reported in Table 1. Perhaps in anticipation of the GATT, tariffs increased between 1984 and 1985. When Mexico joined the GATT in 1986, tariffs dramatically fell until 1988, at which time they increased slightly and stabilized.

Several authors have suggested that the structure of tariffs protected low-wage workers in pre-reform Mexico (Revenga 1997, Hanson and Harrison 1999) and in other developing countries (Currie and Harrison 1997). To examine this hypothesis, I first calculate one common measure of factor intensity, the non-production/production worker ratio, for each industry (in subsequent sections, I add and compare other measures of skill intensity, but these are not available for 1985). 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.[1] As noted earlier, tariffs increased between 1984 and 1985 and then fell until 1988.

Figure 1 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. This affirms Hanson and Harrison (1999) and others who find that the pre-reform structure of tariffs protected less-skilled workers. Figure 2 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.

[1] 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.

B. The Rise in Wage Inequality

As in other developing countries (Robbins 1995), trade liberalization in Mexico was accompanied by an increase in wage inequality. Figure 3 presents data from the Mexican *National Urban Employment Survey* (or ENEU, from its Spanish acronym) from eight Mexican metropolitan areas[2] and shows both the coefficient of variation of log wages and the return to education for each quarter between 1987 and 1995.[3] The rise in the return to education follows the coefficient of variation of log wages rather closely.[4] These findings are consistent with those of Cragg and Epelbaum (1996), Revenga (1997), and Hanson and Harrison (1999).[5] These papers attribute the rise in wage inequality to a rising demand for skill.

The Stolper-Samuelson theorem attributes a rise in wage inequality to an increase in the demand for skill between industries. To calculate the relative importance of *between* and *within* industry changes in demand for skill, I turn to the Mexican Monthly Industrial Survey (*Encuesta Industrial Mensual, or* EIM). The survey covers 3,172 manufacturing firms in 129 4-digit classes of industrial activity. The National Institute of Geography, Information, and Statistics (*INEGI*) conducts the survey. The survey is used to construct indicators of industrial activity. The data exclude firms in the *maquiladora* industry[6] and firms with less than 6 employees. The data do not include information on temporary or unpaid workers (in 1988, unpaid workers made up only about 10% of manufacturing employment).[7]

Table 2 contains the summary statistics from the EIM by two-digit industry. There are significant differences in average hourly wages across industries that are not generally stable

[2] Mexico City, Mexico State, Monterrey, Guadalajara, Tijuana, Ciudad Juarez, Nuevo Laredo, and Matamoros.
[3] Data for earlier years are not available.
[4] 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.
[5] Currency movements also influenced relative prices, confounding the effects of tariff changes. Mexico's peso was devalued in 1987, making 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.

through time (Cragg and Epelbaum 1996, Robertson 1999a). These differentials are incorporated explicitly in subsequent sections. The largest industries, both in terms of employment and sales, are Machinery, Food Products, and Chemicals. Chemicals, Food Products, and Metal Products have the highest non-production/production employment ratios.[8,9] I follow Lawrence and Slaughter (1993) and divide the 127 industries into those that intensively use production workers and those that intensively use non-production workers. As mentioned earlier, use of the production/non-production distinction as a proxy for skill intensity has been criticized in U.S. studies. However, in Mexico this distinction seems to capture much of the skill segregation within industries. The last three columns in Table 2 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.

I classify those with non-production/production employment ratios above the median in each period as non-production-worker intensive. The change in the ratio of non-production (higher skilled) to production worker (less skilled) wages is shown in Figure 4. The change in relative wages mimics those found in Figure 3. The ratio increases from about 2.5 to over 3 during the 1987-1995 period.[10]

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[6] 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. These firms are included in the firm-level surveys used later in this paper.
[7] Unpaid workers include apprentices and family members.
[8] Mexico also has a higher share of total employment in these industries than the U.S. (see Robertson 1999a).
[9] While the computer industry remains problematic in U.S. price studies of the early 1980s, it is not an outlier in the Mexican data. Therefore, I do not control separately for the computer industry in the analysis that follows. Slaughter (1998) argues that the computer industry should not be excluded even if it is an "outlier" because, as such, it may contain important information.
[10] Blonigen and Slaughter (1999) find that in the U.S. over the 1979-1994 period, the non-production/production worker wage ratio rose from 1.52 to 1.67.

The essence of the Stolper-Samuelson theorem is that the change in prices between industries causes skill-intensive industries to expand, thus increasing the demand for skill between industries. The Mexican Monthly Industrial Survey data are ideal for decomposing the increase in skill demand into the contribution of *between* industry forces (such as changes in relative output prices) and *within* industry factors (such as skill upgrading). To decompose the change in the demand for skilled workers, I calculate the familiar decomposition:

$$DE = \sum_j \bar{s}_j De_j + \sum_j \bar{e}_j Ds_j$$

(total = within + between)

where DE 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 would cause a between-industry shift towards skilled workers, which, given fixed factor supplies, would have to be offset 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% - a relatively large increase for such a short time period. Extending the period to 1995 produces 0.041 = 0.021 (between) + 0.019 (within). Over the 1987-1995 period the relative employment of skilled workers in manufacturing increased over 8%. The decomposition reveals that the change in skill demand over the 1987-1994 period was about equally divided between *between* and *within* effects.[11]

III. The Role of Stolper-Samuelson Effects

This section employs three approaches to evaluate the hypothesis that Stolper-Samuelson forces can explain relative price movements in Mexico. In part A, I perform simple "consistency checks" for conditions that must hold if SS forces are at work. In part B, I employ time-series techniques to test whether relative wages and relative prices are cointegrated. In part C, I apply the mandated wage approach first proposed by Baldwin and Hilton (1984) and recently applied by Baldwin and Cain (1997), Leamer (1998), Feenstra and Hanson (1999) and Haskel and Slaughter (1999). All three approaches provide evidence supporting the Stolper-Samuelson theorem in the Mexican case.

A. Necessary and Sufficient Conditions for Stolper-Samuelson Effects

The first condition of the Stolper-Samuelson theorem involves relative price movements. Did the relative price of production- or non-production-worker-intensive goods increase? There are two approaches to this question. As in Lawrence and Slaughter (1993), I regress the change in prices (dP_j) over the sample period on the ratio of non-production to production workers (H/L) at the beginning of the sample period:

$$dP_j = a + b(H/L)_j + e_j \,. \qquad (5)$$

[11] Robertson (1999b) evaluates the hypothesis that the *within* industry component of skill upgrading was a

To estimate (5) I use survey output data and product-price data. The price data are collected in the industrial survey but are collected at the product level. I aggregate product level prices to the four-digit industry level. 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 the Appendix.

Table (3) presents the regression results for the Mexican data for the period following trade liberalization.[12] The effect of price changes may be sensitive to endpoints because Mexico experienced currency devaluations in 1987 and 1995. The North American Free Trade Agreement between Canada, the United States, and Mexico went into effect in January 1994. I present four regressions for each of three measures of skill intensity. Each column in Table 3 contains the results from a separate regression using different endpoints (1987-1995, 1988-1995, 1987-1994, and 1988-1994). Each regression is estimated using weighted least squares using the mean value of output over 1987-1995 as weights.[13] The first four rows contain the results from regressions of the change in relative price on the 1987 mean ratio of non-production to production workers. All of point estimates are positive and two are significant. These results suggest that the output price of skill-intensive industries increased relative to less-skill-intensive industries following trade liberalization.

In the second panel of rows in Table 3, I apply Krueger's (1997) measure of skill intensity: the employment share of production workers. The results are consistent with those in the first panel of Table 3. Industries with higher shares of production workers had smaller price changes. The last panel further corroborates this finding (though more weakly) using average education levels of the workers within each industry, calculated using household-level data. All of the

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result of the effects of international factors on the firm's technology choice.

[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 (1998) discusses the robustness of results found with and without computer-industry controls.

[13] Krueger (1997) uses weights and Slaughter (1998) discusses the robustness of using weights. They are appropriate for the Mexican case because of the large variance in industry employment.

coefficients are positive and one is statistically significant. Industries with higher average levels of education had greater price changes over the sample period.

Another way to examine the changes in prices and factor intensities is to take advantage of the panel aspect of the data. Analyzing the between-industry price movements and relative employment over time also reveals whether changes in relative prices were higher for more non-production-worker-intensive industries. Table 4 shows the (weighted) *between* industry regressions of

$$lnP_{ij} = a + b\ ln(H/L)_{ij} + e_{ij} \tag{6}$$

$$lnP_{ij} = a + b\ ln(L/(H+L))_{ij} + e_{ij} \tag{7}$$

$$lnP_{ij} = a + b\ ln(education)_{ij} + e_{ij} \tag{8}$$

The between-industry regressions in equations (6) - (8) is equivalent to a regression on the means within industries (over time). A positive coefficient in (6), for example, suggests that, on average, industries with higher non-production/production worker ratios experienced larger increases in prices. The results in Table 4 suggest that there is a significant and positive relationship between skill intensity and the change in the output price. 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 different measures of skill intensity; the results from equation (8) are very similar to the results from equations (6) and (7).

The next condition is not strictly necessary for the presence of Stolper-Samuelson effects but, if present, plays a very important role. 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). As a first step to testing this prediction, I perform a fixed-effects panel regression of both the output share and employment share on industry output price with and without a time trend. The effects of prices on output and employment share are found in Table 5. Industries 3512 (agricultural and hand tools) and 3820 (construction and repair of rail equipment) lack price data and are dropped. The regressions include a fixed effect for 126 of 127 four-digit industries. That is, I perform the regression:

$$y_{it} = a_0 + a_i + bp_{it-1} + e_{it} \tag{9}$$

in which y_{it} is either the output share (the value of output in industry i in period t divided by the sum of the value of output across all 4-digit industries within period t) or the employment share (constructed in the same way as the output share).

Table 5 shows that, as expected, both output and employment shares positively respond to price increases. The coefficient on log industry price is positive and significant, suggesting that, on average, a 10% increase in the price index (relative to the CPI) increases the industry output share by 4.1% the industry employment share by 1.6%. This result should not be surprising since it is consistent with the simplest model of competitive, price-taking firms with rising marginal costs.

Results in Tables 3-5 demonstrate a between-industry shift in employment towards non-production-worker-intensive industries.[14] Price changes favored non-production-worker intensive industries and these industries expanded as a result. This between-industry shift raised the demand for non-production workers. If the labor supply curve is not horizontal, this increase in demand would raise the relative wages of non-production workers.

These results suggest that Mexican tariffs protected less-skill-intensive industries, that the relative price of skill-intensive goods increased when those tariffs were reduced, and, as a response to the change in relative prices, the skill-intensive industries expanded. Together, the findings from the previous section are consistent with the SS theorem, but do not directly support the relationship represented in (4). Ideally, solving equation (4) for wages as functions of prices and estimating these functions would determine the effect of changes in prices on wages, but

[14] Regressing the change in the employment share on a dummy variable that is equal to 1 if the industry is production worker intensive also generates a negative and significant coefficient (results available from the author upon request).

dimensionality makes solving (4) difficult. Specifically, (4) 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. One solution to this problem is addressed with the time-series approach discussed in the next section.

B. A Time Series Approach

Using two classifications of workers (skilled and unskilled), Francois, Navia, and Nelson (1998) circumvent the dimensionality problem by dividing industries into two groups based on factor intensity. Since there are only two factors (skilled and unskilled workers) and only two goods (based on factor intensity), the factor share matrix in (4) can be inverted to yield

$$\hat{\boldsymbol{w}} = \hat{\boldsymbol{p}} \, Q^{-1} \tag{10}$$

which Francois, Navia, and Nelson interpret as representing the relationship between relative prices and relative wages over time.

Francois, Navia, and Nelson follow Borjas and Ramey (1994) and Baldwin and Cain (1997) when constructing their relative wage series, and when computing relative prices. 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. The second is that the difference between the two series be stationary. Only if the first condition is satisfied is the second condition considered. Francois, Navia, and Nelson find weak evidence that the two series exhibit a unit root and then weak evidence that the relative wages and relative prices are cointegrated. However, they admit that their results are not very robust across various lag structures.

To perform a similar analysis with the Mexican data, I classify the Mexican manufacturing industries into two groups based on the median ratio of production to non-production workers.

Using this classification, I then calculate the production-weighted ratio of the output price indices of the two groups. Since the data already include wages for production and non-production workers, I calculate the employment-weighted relative wage. Figure (4) graphs the movements of relative prices and relative wages. The two series follow closely together throughout the sample period until NAFTA went into effect in 1994.[15]

While Figure (4) seems to suggest that the two variables are closely related over time, each condition for cointegration must be considered. 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. Given these lag lengths, I then apply the augmented Dickey-Fuller unit root test 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.[16]

The next step is to test for cointegration. I follow the Engle-Granger approach as described in Engle and Yoo (1987). The Engle-Granger approach tests the stationarity of the residuals of

$$ln w_t = a + b \, ln \, p_t + z_t \qquad (11)$$

in which w_t represents the ratio of non-production worker wages to production worker wages and p_t represents the ratio of the price of non-production-worker intensive goods to production-worker-intensive goods. Again using the augmented Dickey-Fuller test for stationarity, the test statistic (p-value) is -1.15 (0.870) which indicates a failure to reject the null of no cointegration.

[15] The apparent structural change that takes place when NAFTA went into effect may not be surprising. When Mexico joined the GATT in 1986, it significantly lowered trade barriers to the rest of the world. In terms of factor endowments, Mexico may look very different to the United States and Canada than it does to the rest of the world. Furthermore, by joining NAFTA, Mexico may have reduced protection for a different set of industries than it reduced for the GATT. While further exploration of the effects of NAFTA *vs.* GATT is interesting, it is beyond the scope of the present paper.

[16] Including a trend did not affect the qualitative results.

Even though the two series are not cointegrated, it is still interesting to extend the Francois, Navia, and Nelson analysis and perform (4) with monthly data because the Stolper-Samuelson theorem (and the trade theorists single-cone response to factor-content studies) suggests that relative prices drive relative wages. Time series techniques can be used to test this facet of the trade/wages relationship.

OLS estimation results of (10) generate a coefficient (standard error) of relative prices of 1.418 (0.262). While this would seem to be consistent with the Stolper-Samuelson theorem, the resulting Durbin-Watson statistic (0.344) suggests that the error terms are serially correlated. In the presence of adjustment costs for employment and wages, the error terms would be serially correlated if lagged dependent variables, which capture the persistence of changes, were omitted from the regression. Table 6 contains the results of estimating (4) with a more complex lag structure. Three lags of wages are sufficient to eliminate the serial correlation as shown by Dubin's *h* statistic in Table 6. To examine the effects of prices, I also include 6 and 12 lags of the relative prices (with and without a time trend). The results in Table 6 show that when serial correlation is corrected, the first lagged price coefficient is negative. Up until the last lags (6 or 12), the pattern is oscillating. The test for Granger causality, which is a test that the price coefficients are jointly zero, also fails to reject the hypothesis that short-run price changes drive wages.

The long run-effects, while measured imprecisely, are positive in every case in Table 6.[17] The net effect of prices on wages is greater than one. This result is consistent with the Jones (1965) magnification effect that suggests that the change in wages following a price change will be larger than the change in prices. Of course, the earlier finding of a unit root in both series casts doubt on these results.

[17] Including a time trend significantly dampens the long-run effect of prices. Including the time trend does not follow from the Stolper-Samuelson theorem and thus the results with the time trend should be taken lightly.

Given the fact that the data were found to have a unit root, I next take the first difference of both series to make them stationary. The regression results for the differenced series are found in Table 7. The results are qualitatively similar to those in Table 6. The first lagged difference of prices has a negative effect on the change in relative wages, but the second lag has a stronger, positive effect. In all cases, the long-run effects of changes in prices (the sum of the coefficients) are positive although less than one and statistically insignificant. The trend term is not statistically significant in the differenced-data regressions and does not affect the results.

Overall, the time series results provide weak evidence that monthly price variation drives changes in relative wages. The imprecision of the estimates may not be surprising given several strict assumptions necessary to perform this approach. For example, the approach assumes minimal adjustment costs. In the presence of adjustment costs, factors may not respond rapidly enough for SS forces to be detected in the high-frequency data. That is, the Stolper-Samuelson "clock" may tick less than once a month. Furthermore, the results in Tables 6 and 7 provide the effects of a single shock to prices on wages. That result, while positive, is very noisy. However, Mexico did not experience just one price shock. Tariffs and import controls were relaxed over a period of several years. Figure (3) suggests that relative prices followed a long upward trend. Taken together, the sum of the individual changes in relative wages may have had significant effects.

C. The Mandated Wage Approach

The time series results are consistent with the hypothesis that price shocks drive relative wages, but factors need time to adjust. Given the sustained rise in relative prices that occurred in Mexico, the mandated wage approach may capture the cumulative effect of the changes in relative prices that took place over the 10-year period. Mandated wage equations test the relationship between the change in prices and the change in wages over long time periods (generally nine or ten years).

To test the long-run relationship between wages and prices, the mandated wage approach compares predicted changes in wages with actual changes. The accuracy of the predictions provides information about the determinants of wage movements. 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 other factors, such as changes in technology. Consistent with previous sections, I find that the mandated wage approach predicts increasing wage inequality in Mexico.

This approach has been contentious in the U.S. and the literature has identified four key estimation issues. The first concerns the exogeneity of price changes. The SS theorem assumes that prices are exogenous. The application of this approach to the U.S. has generated conflicting results for the United States. This should not be surprising if the world market does not determine U.S. prices, as the SS theorem assumes. The advantage of studying the small country is that prices and technology are assumed to be exogenous. The price changes that followed the tariff changes seem to strongly support the exogeneity of price changes in Mexico during this time period because relatively larger tariff reductions on less-skill-intensive goods were followed by relatively larger price reductions on less-skill-intensive goods. Nonetheless, I test the robustness of the results to controls for endogeneity found in U.S. studies.

The second issue has not been addressed in most wage studies. As Lawrence (1999) and Haskel and Slaughter (1999) point out, trade may cause technical improvements that affect the relative demand for skill. Thus, trade may contribute to within-industry skill upgrading. This issue is addressed directly by Robertson (1999b) and thus is not fully addressed here. What must be addressed for the purposes of this paper is the assumption that technology is exogenous. There is considerable evidence that Mexican firms do take technology as given. In 1992, INEGI conducted a firm-level survey of 5071 manufacturing firms.[18]

[18] 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.

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).[19] 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. I make that assumption in the empirical work that follows.

The third estimation issue involves value-added prices. Slaughter (1998) 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 in 0.9033. The findings are qualitatively robust to using value-added prices and accounting for intermediate inputs.

Feenstra and Hanson (1999) introduced the fourth estimation issue. They argue that when total factor productivity and changes in inter-industry wage differentials (iiwds) are introduced into the mandated wage equations, the equations become an identity. In Haskel and Slaughter's

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

(1999) study of U.K. wage inequality, they argue that iiwds are stable in Great Britian and so do not affect the analysis. Neither Feenstra and Hanson nor Haskel and Slaughter control for differences in demographic characteristics when examining iiwds. Controlling for demographic characterisics with household-level survey data, Robertson (1999a) finds that iiwds are not stable in Mexico over the 1987-1995 period. However, when changes in iiwds are incorporated into the Mexican mandated wage regressions, the equation does not behave in the same way as Feenstra and Hanson find (i.e. the equation does not behave as an identity). Nonetheless, the findings are qualitatively similar when iiwds are included, as discussed in detail in the following paragraphs.

Baldwin and Cain (1997) interpret (4) with the following regression equation:

$$\hat{p}_j = a + \sum_i \hat{w}_i q_{ij} + e_j \qquad (12)$$

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. The circumflexes (^) indicate percentage changes. 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.

I estimate equation (12) using the average factor shares in 1987 and the change in the output price index for each industry using the same four endpoints and samples as in the earlier analysis. The regression includes 127 manufacturing industries. As in Baldwin and Cain, I use the value of industry output as regression weights.

The actual changes in average hourly wages and the results from (12) are found in Table 8. There is a clear difference between the mandated change in wages for production and non-production workers in all regressions. 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. Although somewhat imprecise at times, all of the point estimates are consistent with the Stolper-Samuelson theorem and the predicted changes are similar to the actual changes.

Although the results in Table 8 support the Stolper-Samuelson theorem, 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. Price data from the Survey concord with 45 of the 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 (12) with the Census data and value-added prices are found in Table 9. 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).

When unconstrained, the mandated wage changes suggest that wage inequality should have *decreased* with very large drops in non-production worker wages. When constrained, the estimated coefficients suggest that the wage inequality should have increased. Constrained factor shares seem to provide a more intuitive representation of factor intensity, but these contrasting results suggest that the mandated wage approach is sensitive to specification. One possible reason for this sensitivity is omitted variable bias. One key candidate for such a variable is technology.

In Table 10, I include two measures of technology. The first two columns show results when the difference between the change in output and the change in factor inputs (the common measure of total factor productivity) is included in the mandated wage equation. Feenstra and Hanson (1999) argue that the specification of the mandated wage equation is made complete (and thus the mandated wage equation becomes and identity) when technology is adjusted for changes in inter-industry wage differentials.

Including technology improves the fit of all equations, but the adjusted R^2 never approaches the 0.999 the Feenstra and Hanson (1999) find with U.S. data, although the methodology used here is the same. Changes in technology enter significantly in all equations suggesting that prices rose in industries that had larger gains in technology.[20] When technology is included, the predicted change in wages is much closer to those actually observed in Mexico. This is especially true in column (1). Point estimates in all four columns in Table (4) are consistent with the Stolper-Samuelson theorem in that they all "mandate" larger changes in non-production wages and smaller (indeed in two cases negative) changes in production-worker wages. The coefficients are not measured very precisely, and the necessary aggregation to the census data may contribute to the imprecision. Nonetheless, the point estimates are consistent with the results generated with the Survey data (once technology changes are accounted for).

The Stolper-Sameulson forces suggested by 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.[21]

[20] 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).

[21] 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.

IV. Conclusions

Using data from a small, recently liberalized economy, this paper compares movements in prices and wages against the predictions of the Stolper-Samuelson theorem. The current literature suggests that four conditions must hold to accredit SS forces with changes in relative wages. First, the prices of skill intensive goods must have risen relative to the prices of less-skill intensive goods. Second, the output shares of skill-intensive industries must have expanded. Third, the long-run relationship between relative prices and relative wages should be positive. Fourth, for a given vector of factor shares, the wage changes predicted by the SS framework outlined above should be equal to actual wage changes. If the predicted values fall short of the actual values, then SS forces do not explain the changes in relative wages.

This paper finds evidence supporting all four conditions in the Mexican case. The rising relative prices of skill-intensive goods led to the expansion of skill-intensive industries, thus increasing the demand for skilled labor. Using both a time-series analysis and the "mandated wage" approach, this paper also finds that rising wage inequality could be explained by rising relative prices. Since all four conditions are satisfied, this paper provides strong and consistent support for the Stolper-Samuelson explanation for wage movements in Mexico.

Why did Mexico initially protect less-skill-intensive industries? This pattern of protection seems to pose a challenge to the Heckscher-Ohlin theorem. Wood (1997) suggests that relative to the Asian countries, Mexico may not be relatively abundant in less-skilled workers. In any case, this paper suggests that, given the pattern of initial protection and reduction in trade barriers, price changes seem to have driven the wage changes in this small country case, as the Stolper-Samuelson theorem predicts.

These findings also support those who argue that trade could have affected U.S. wages to the extent that this paper supports the Stolper-Samuelson theorem. Attempts to control for the endogeneity of technology and prices seem to be an appropriate way to adapt the Stolper-Samuelson theorem to the large country case.

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. As noted in the text, 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 jewellery 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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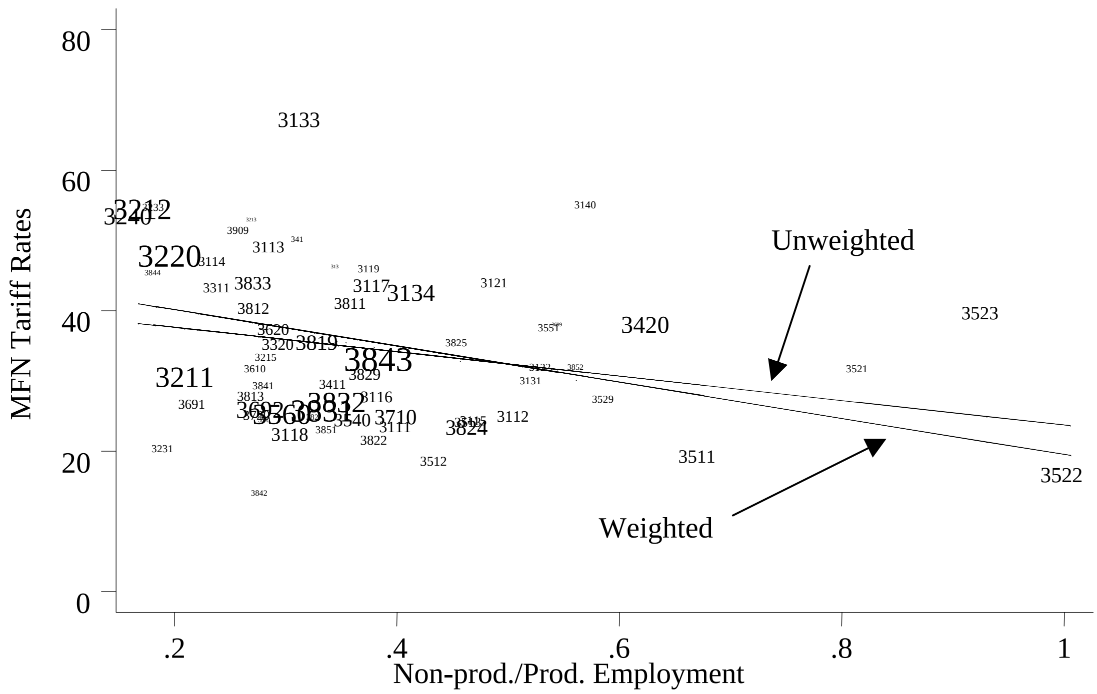
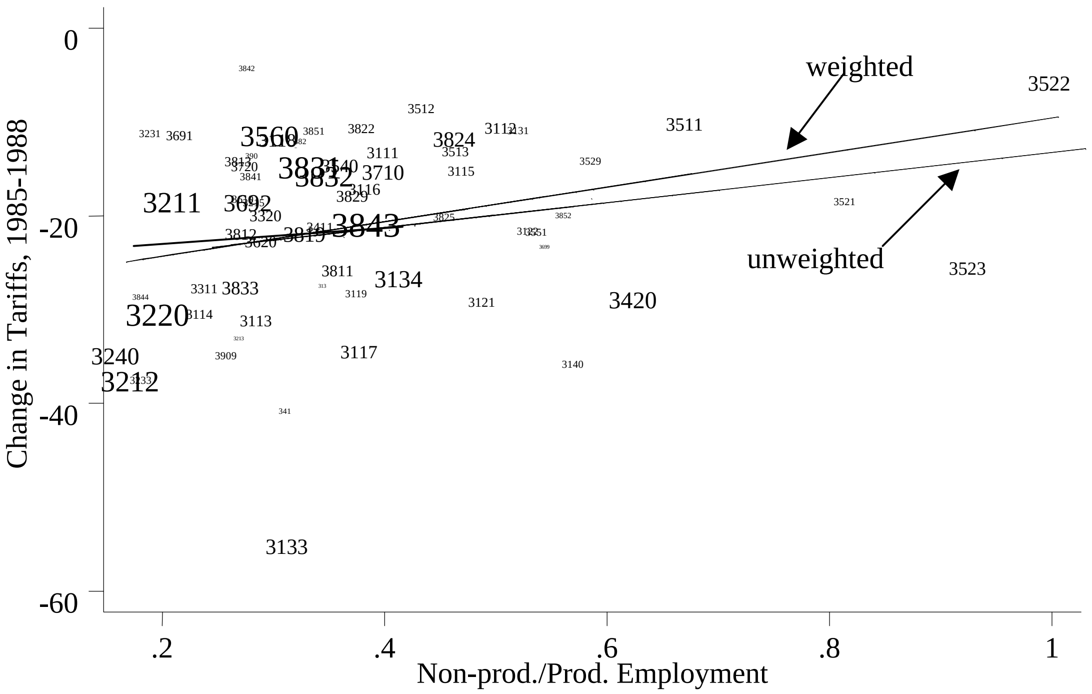
Figure 1: AverageTariff Levels and Relative Employment: 1985



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 2: 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 3: Wage Inequality and Increasing Returns to Skill in Mexico: 1987-1996

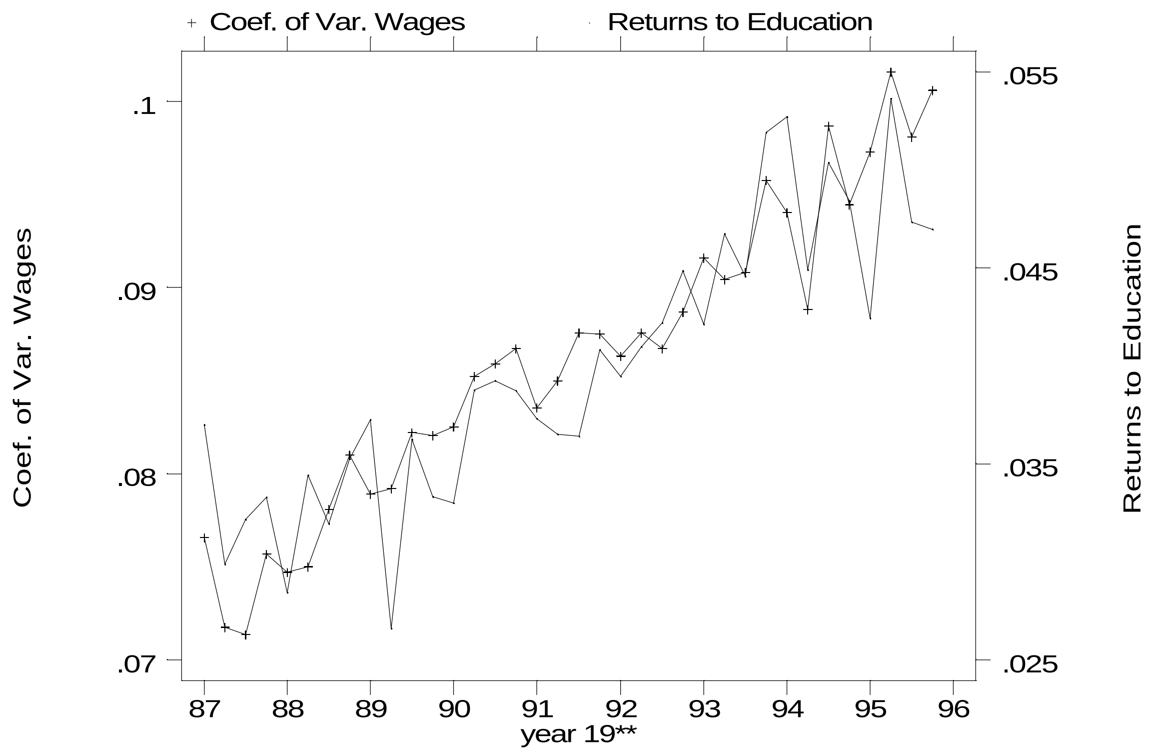


Figure 4: Relative Price and Wage Movements in Mexico, 1987-1996

Notes: For both series, “relative” implies the non-production/production worker ratio.

Table 1: Average Tariffs and Import-License Requirements by Two-Digit Industry, 1984-1990 (%)

Industry	H/L	1984	1985	1986	1987	1988	1989	1990
Food	0.584	42.9	45.4	32.1	22.9	14.8	15.8	16.2
Textiles	0.323	38.6	43.2	40.4	26.6	16.8	16.6	16.7
Wood	0.325	47.3	48.5	44.9	29.9	17.7	17.6	17.8
Paper	0.383	33.7	36.5	34.8	23.7	7.7	10.1	9.9
Chem.	0.797	29.1	29.9	27.0	20.5	13.4	14.3	14.4
Glass	0.420	37.1	38.5	33.8	22.4	13.8	14.3	14.3
Metals	0.440	13.6	16.7	18.4	13.8	7.9	11.0	11.0
Mach.	0.512	43.1	46.3	30.0	20.8	14.1	15.9	16.1
Other	0.399	40.9	42.9	40.5	27.5	17.1	18.1	18.4

Notes: Source: Hanson and Harrison, 1999, except for the second column. In the second column, H/L is the ratio of the number of non-production workers to the number of production workers and is identical to column (H/L) in Table 3. 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.

Table 2: Summary Statistics for Mexican Manufacturing 1987-1995

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 3: Price Changes and Initial Skill Intensities

	87-95	88-95	87-94	88-94
H/L	0.091	0.080	0.194	0.199
	(0.057)	(0.061)	(0.052)	(0.057)
intercept	-0.239	-0.178	-0.404	-0.362
	(0.037)	(0.040)	(0.034)	(0.037)
adj. R-sq.	0.013	0.006	0.098	0.087
N	117	117	117	117
L/(H+L)	-0.312	-0.267	-0.634	-0.652
	(0.186)	(0.201)	(0.171)	(0.187)
intercept	0.021	0.046	0.131	0.188
	(0.128)	(0.139)	(0.118)	(0.129)
adj. R-sq.	0.015	0.007	0.098	0.088
N	117	117	117	117
Education	0.042	0.061	0.008	0.023
	(0.022)	(0.024)	(0.022)	(0.024)
intercept	-0.579	-0.706	-0.371	-0.464
	(0.208)	(0.222)	(0.204)	(0.220)
adj. R-sq.	0.021	0.047	-0.008	-0.001
N	117	117	117	117

Notes: H represents non-production workers. L represents production workers. Education is measured in years. The 129 industries in the Industrial Survey were aggregated into the 117 identifiable industries in the household level data. Standard errors are in parentheses.

Table 4:
Between-Industry Regressions of Prices on Skill Measures

	ln(H/L)	ln(L/(H+L))	ln(av. educ)
skill	0.072	-0.232	0.109
	(0.010)	(0.026)	(0.011)
cons	4.656	4.506	4.367
	(0.023)	(0.019)	(0.032)
chi-sq	10656.72	10661.12	9821.23
p-value	0.000	0.000	0.000
N	13715	13715	12791

Notes: H represents non-production workers. L represents production workers. Education is measured in years. Results are generated with Stata®'s xtgee command (generalized estimation equation) with 107 time effects (all months in the 1987 to 1995 period, less one) and weighted by the average output value. The dependent variable is the output price index. Standard errors are in parentheses.

Table 5: Relation Between Prices and Output, Employment Shares

$$y_{it} = a_0 + a_i + bp_{it-1} + e_{it}$$

	y = Output Share		*y* = Employment Share	
lag price	0.409	0.339	0.164	0.151
	(0.009)	(0.011)	(0.005)	(0.006)
time		-0.012		-0.002
		(0.001)		(0.001)
constant	-7.348	-5.987	-6.049	-5.735
	(0.039)	(0.125)	(0.024)	(0.072)
F-test Fixed fx	2194.963	2216.283	4297.114	4299.338
p-value	0.000	0.000	0.000	0.000
R-squared	0.135	0.143	0.071	0.072
N	13587	13587	13588	13588

Notes: The data in the regression include 127 industries pooled over 108 time periods. The standard errors are in parentheses. The F-test is a test of the joint significance of 126 industry dummy variables (the fixed effects). The variable *time* is a linear time trend. The lagged price is the 4-digit price index lagged one month. The regression technique is OLS with the classical error assumptions.

Table 6: Log-Level Time Series Equations

	(i)	(ii)	(iii)	(iv)
w-1	0.370	0.377	0.246	0.229
	(0.109)	(0.111)	(0.110)	(0.110)
w-2	0.310	0.218	0.185	0.081
	(0.115)	(0.120)	(0.116)	(0.117)
w-3	0.260	0.290	0.123	0.137
	(0.107)	(0.111)	(0.110)	(0.111)
p-1	-0.226	-0.223	-0.204	-0.218
	(0.207)	(0.207)	(0.197)	(0.192)
p-2	0.466	0.488	0.464	0.510
	(0.256)	(0.257)	(0.244)	(0.239)
p-3	-0.268	-0.350	-0.284	-0.356
	(0.253)	(0.259)	(0.240)	(0.240)
p-4	0.334	0.495	0.345	0.481
	(0.245)	(0.255)	(0.233)	(0.236)
p-5	-0.313	-0.402	-0.247	-0.304
	(0.247)	(0.255)	(0.236)	(0.237)
p-6	0.106	0.417	0.115	0.408
	(0.203)	(0.249)	(0.193)	(0.231)
p-7		-0.355		-0.248
		(0.248)		(0.231)
p-8		-0.121		-0.073
		(0.251)		(0.233)
p-9		-0.100		-0.085
		(0.257)		(0.238)
p-10		0.092		0.020
		(0.252)		(0.234)
p-11		-0.138		-0.212
		(0.254)		(0.236)
p-12		0.331		0.097
		(0.222)		(0.215)
trend			0.020	0.026
			(0.006)	(0.007)
Test joint sig: wages p-value	0.000	0.000	0.000	0.010
Sum wage coefficients	0.060	0.114	0.446	0.554
Sum wages p-value	0.200	0.100	0.000	0.000
Long-run effect: wages	16.590	8.756	2.243	1.806
Test joint sig: prices p-value	0.410	0.320	0.280	0.270
Sum price coefficients	0.100	0.136	0.189	0.019
Sum prices p-value	0.490	0.500	0.180	0.920
Long-run effect: prices	1.660	1.194	0.423	0.035
Number of Observations	102	96	102	96
Adj-R-squared	0.871	0.837	0.883	0.860
Durbin-Watson's h stat.	0.817	1.034	1.147	0.927
D-W h stat p-value	0.414	0.301	0.251	0.354

Table 7: Log-Differenced Time Series Equations

	(i)	(ii)	(iii)	(iv)
w-1	-0.565	-0.487	-0.563	-0.487
	(0.110)	(0.117)	(0.111)	(0.119)
w-2	-0.245	-0.257	-0.243	-0.257
	(0.122)	(0.125)	(0.123)	(0.127)
w-3	0.095	0.130	0.098	0.130
	(0.113)	(0.119)	(0.115)	(0.121)
p-1	-0.180	-0.127	-0.174	-0.127
	(0.207)	(0.215)	(0.210)	(0.220)
p-2	0.255	0.326	0.261	0.326
	(0.206)	(0.212)	(0.210)	(0.217)
p-3	0.053	-0.017	0.061	-0.017
	(0.215)	(0.221)	(0.220)	(0.227)
p-4	0.405	0.465	0.410	0.465
	(0.204)	(0.215)	(0.207)	(0.222)
p-5	0.035	-0.060	0.038	-0.060
	(0.200)	(0.220)	(0.202)	(0.225)
p-6	0.463	0.487	0.468	0.487
	(0.193)	(0.213)	(0.195)	(0.223)
p-7		0.046		0.046
		(0.217)		(0.226)
p-8		0.004		0.004
		(0.217)		(0.232)
p-9		-0.119		-0.119
		(0.218)		(0.231)
p-10		-0.012		-0.012
		(0.215)		(0.227)
p-11		-0.238		-0.238
		(0.208)		(0.216)
p-12		0.048		0.048
		(0.219)		(0.224)
trend			0.000	0.000
			(0.002)	(0.002)
Test joint sig: wages p-value	0.000	0.000	0.000	0.000
Sum wage coefficients	1.715	1.613	1.707	1.614
Sum wages p-value	0.000	0.000	0.000	0.000
Long-run effect: wages	0.583	0.620	0.586	0.620
Test joint sig: prices p-value	0.100	0.290	0.100	0.300
Sum price coefficients	1.030	0.804	1.064	0.803
Sum prices p-value	0.130	0.500	0.130	0.550
Long-run effect: prices	0.601	0.498	0.623	0.498
Number of Observations	101	95	101	95
Adj-R-squared	0.304	0.275	0.297	0.266
Durbin-Watson’s h stat.	0.209	1.721	0.076	2.055
D-W h stat p-value	0.835	0.085	0.939	0.04

Table 8: Mandated Wage Equation Results

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

		Change in Prices over period:			
		87-95	88-95	87-94	88-94
production workers	predicted	-1.556	-1.752	-1.062	-1.189
		(0.821)	(0.874)	(0.816)	(0.876)
	actual	-0.128	0.010	0.005	0.164
	p-value	0.085	0.046	0.193	0.125
non-production workers	predicted	1.631	0.840	2.257	2.134
		(1.067)	(1.029)	(1.060)	(1.031)
	actual	0.149	0.123	0.583	0.548
	p-value	0.167	0.487	0.117	0.126
	N	127	127	127	127
	Adj-R2	0.013	0.018	0.021	0.018

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 9: Mandated Wage Regressions (Census Data)
Without Productivity

	88-93 (1)	87-94 (2)	88-93 (3)	87-94 (4)
Non-Production	-4.534	-4.374	1.538	1.126
	(2.710)	(2.635)	(1.422)	(1.351)
Production	0.516	0.382	0.181	0.084
	(1.293)	(1.257)	(0.912)	(0.867)
Capital	-3.385	-2.816	-0.824	-0.548
	(1.479)	(1.438)	(0.993)	(0.943)
Materials	-1.217	-1.056		
	(0.305)	(0.297)		
Constant	0.599	0.450	-0.266	-0.305
	(0.202)	(0.196)	(0.102)	(0.096)
N	43	43	43	43
Adj. R^2	0.257	0.203	-0.026	-0.049

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. Standard errors are in parentheses.

Table 10: Mandated Wage Regressions (Census Data) With Productivity

	88-93 (1)	87-94 (2)	88-93 (3)	87-94 (4)
(e) TFP	0.713	0.783	0.456	0.496
	(0.186)	(0.165)	(0.231)	(0.185)
Non-Production	0.760	0.271	2.056	0.956
	(1.241)	(1.100)	(1.397)	(1.256)
Production	0.168	0.070	-0.061	-0.474
	(0.786)	(0.696)	(0.889)	(0.831)
Capital	-0.805	-0.527	-0.846	-0.201
	(0.855)	(0.757)	(0.958)	(0.885)
Constant	-0.246	-0.284	-0.243	-0.281
	(0.088)	(0.078)	(0.099)	(0.090)
N	43	43	43	43
Adj R^2	0.240	0.324	0.045	0.095

Notes: Columns (1) and (2) include Total Factor Productivity (TFP) calculated as the difference between the change in inputs and the change in output. Columns (3) and (4) include TFP adjusted by changes in inter-industry wage differentials (eTFP). Factor shares are constrained to sum to one in all four regressions. The dependent variable is the change in the value-added price in each period. Standard errors are in parentheses.