What is the effect of trade on the gender wage gap in the Mexican manufacturing sector?

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Abstract

This study examines the effect of trade-induced price changes on the gender wage gap in Mexico before and after the North American Free Trade Agreement (NAFTA) in 1994. By applying the Stolper-Samuelson Theorem, a result in trade theory that links relative goods prices and relative wages, this paper tests whether changes in relative prices of female-intensive goods can explain changes in female relative wages. Using household employment surveys and production data from Mexico's National Institute of Geography and Statistics (INEGI) for the 1988 to 2010 period, we find that (1) the gender wage gap in manufacturing has increased after NAFTA and (2) there is a statistically significant and positive long-run relationship between relative output prices and relative wages.

Keywords: Trade liberalization; Gender Wage Gap; Mexico

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Introduction

Since the late 1980s, Mexico has relied on trade as a development strategy. Mexico began liberalizing its economy by entering the General Agreement on Tariffs and Trade (GATT) in 1986, which led to a dramatic reduction in tariffs.[1] In 1992, Mexico further liberalized its economy by signing the North American Free Trade Agreement (NAFTA), which came into effect in 1994. NAFTA led to the reduction of tariffs and non-tariff barriers and facilitated capital flows across the region (Robertson 2004).

The deepening of globalization has raised concerns on whether international trade has led to the marginalization of the poor, especially women, who are disproportionately vulnerable in developing countries (Wee 1998). Despite the liberalization policies and women's growing share of industrial employment[2], the gender wage gap in Mexico remains large (Dominguez-Villalobos and Brown-Grossman 2010). In 1987 women earned on average 86% of men's wages (Artecona and Cunningham 2002) while in 2005 they earned 75% of men's wages (Dominguez-Villalobos and Brown-Grossman 2010). This has motivated the question of how international trade affects gender wage inequality in labor markets.

By applying the Stolper-Samuelson Theorem, a result in trade theory that links changes in goods prices and changes in relative factor prices, this paper studies whether changes

[1] The maximum effective tariff in manufacturing prior to GATT was 80%. The maximum tariff prior to the NAFTA was 20% (Robertson 2004).
[2] Women's share of industrial employment increased from 26 percent between 1987 and 1993 to 37 percent in 2006.

in relative prices of female-intensive goods can explain changes in female relative wages in the Mexican manufacturing sector before and after NAFTA in 1994.

The results of this study are consistent with a positive long-run relationship between relative prices and relative wages for the 1988 to 2010 period. This relationship holds in manufacturing as well as across all sectors in the economy. Our robustness checks show that the effect of relative prices on relative wages increases when we incorporate a larger number of female intensive industries. Nevertheless, the estimation coefficients obtained are not indicative of a magnification effect[3] of relative prices on relative wages.

This paper has 5 sections. Section 1 examines the past literature on the impact of trade on the gender wage gap. In Section 2, we present the formal derivation of the Stolper-Samuelson Theorem. Section 3 describes our empirical strategy and the data used in this study. Section 4 discusses estimation issues and regression results. Section 5 concludes.

I. Literature Review

The microeconomic factors that influence the gender wage gap have been studied extensively. A more recent literature addresses the gender-differentiated effects of globalization through trade and Foreign Direct Investment (FDI). The impact of trade on women's wages relative to men remains contested and studies have analyzed this question through two main theoretical approaches.

[3] Magnification effect: Changes in output prices have a magnified or more than proportional effect on factor prices (Yarbrough 2006).

First, the neoclassical approach based on Becker's (1971) discrimination model predicts that in a noncompetitive market, employers that have a taste for discrimination against women will hire fewer than the profit-maximizing number of women, and employ men who are equally skilled yet more highly paid. In an open-economy context, this theory predicts that international trade will increase competitive pressures, and as a result firms will engage in cost cutting practices. It is expected that under these new market conditions, costly discrimination will not persist; therefore the gender wage gap will tend to narrow in the long run.

Studies adopting this approach analyze how the gender wage gap (a proxy for discrimination) responds to changes in the competitive environment as a result of trade. Their methodology consists of comparing the impact of foreign trade across concentrated (non competitive) and less concentrated (competitive) sectors. Black and Brainerd (2004) find that increased international trade in the United States led to a decline in discrimination and as a result contributed to the improvement in relative female wages between 1970 and 1980. Their statistically significant and consistent results indicate that the gender wage gap narrowed more rapidly in trade-affected concentrated industries than in trade affected competitive industries. Artecona and Cunningham (2002) conduct a similar study on the Mexican manufacturing sector during the trade liberalization period from 1987 to 1993. Their results are consistent with Black and Brainerd (2004) but statistically significant at only the 20% level.

Berik et al. (2004), on the other hand, find evidence that increasing trade openness is associated with *higher* gender wage gaps in Taiwan and Korea between 1981 and 1999. In Taiwan, greater import competition appears to widen the wage gap by adversely affecting women's relative employment prospects, leading to a loss of bargaining power for women. In this case greater cost cutting pressures due to international competition have increased layoffs experienced by female workers. Menon and Rodgers (2009) adds to this pool of evidence in finding that increasing openness to trade is associated with larger gender wage gaps in India's concentrated manufacturing industries between 1983 to 2004.

There have been few cross-country studies that incorporate Becker's (1971) discrimination model. Oostendorp (2009) analyzes the impact of trade on the occupational gender wage gap[4] and finds that the occupational gender wage gap tends to decrease with increasing economic development at least in developed countries.[5] Also, the occupational gender wage gap tends to decrease with trade and FDI in richer countries, but finds little evidence that trade and FDI also reduce the occupational gender wage gap in poorer countries.

Since studies using the discrimination model generate mixed evidence, other studies apply alternative theoretical frameworks. A second approach is based on the Heckscher-Ohlin framework that predicts that trade expansion should lead to the reallocation of factors to those sectors that intensively use the relatively abundant factor of production. If developing countries are relatively abundant in low-skill labor, trade should increase the demand for, and price of, low-skill labor. Studies using this approach assume that as long as women cluster in low-skilled jobs and men cluster in high-skilled jobs, the

[4] The study is based on the ILO October inquiry database which contains information on the gender wage gap in 161 narrowly defined occupations in more than 80 countries for 1983 to 1999.
[5] These findings are consistent with Boserup's (1970), who suggests that development has to reach a certain threshold before gender gaps close with further economic growth.

increase in the demand for low-skill labor will reduce pay differentials between men and women.

Dominguez-Villalobos and Brown-Grossman (2010) analyzes the effect of export orientation on the gender-wage ratio within industries in Mexico during the 2001-2005 period. The authors argue that the Heckscher-Ohlin framework is inadequate for studying gender wage inequality for the following reasons. First, Mexico experienced a skill reversal in the demand for labor in favor of unskilled workers after 1998. Nevertheless, results indicate that gender wage ratio was negatively associated with the ratio of women's to men's unskilled to skilled labor ratios[6]. In other words, even though women tend to be more unskilled than men it does not follow the relative wage of women will increase in response to increasing demand for unskilled labor.

The common assumption that female workers are unskilled relative to men may not be entirely accurate. **Figure 1(a** and **b**) show the distribution of years of education for working men and women in Mexico in 1995 and 2005. We observe that the distributions are very similar and that there is a significant amount of overlap. As a result there cannot be a clear distinction made between male and female workers on the basis of skill. An alternative application of the Heckscher-Ohlin framework in analyzing gender wage inequality would involve treating female and male workers as completely different factors.

This paper will examine the effect of changes in the relative price of female intensive goods on changes in the relative female wage before and after NAFTA. The advantage of

[6] Unskilled-skilled labor ratio: The number of workers with <3 years of secondary school/the number of workers with ≥3 years of secondary school.

studying Mexico using this approach is that unlike the United States, whose changes in relative prices are affected by factors such as technology, the change in relative prices in Mexico is traced to the exogenous shock of tariff reduction. In this way Mexico may present a more direct example of the link between trade liberalization and relative wages through changes in relative goods prices.

II. Theory

In order to analyze the effect of trade-induced price changes on male and female wages, we begin by adapting a simple trade model. The model is an adaptation of the Stolper-Samuelson Theorem and assumes there are two factors, males (f) and females (f), and two industries, female- intensive industries and male-intensive industries. In addition, the model assumes perfect factor mobility between industries in the long run.

Male and female workers are often assumed to be perfect substitutes and grouped together as one factor of production. For whatever reason, males and females may not be perfect substitutes. In order to treat them as separate factors it is necessary to empirically evaluate whether or not they are imperfect substitutes by estimating the elasticity of factor substitution between male and female labor, which we do in the empirical section. For now, we will simply assume they can be treated as separate factors.

The Stolper-Samuelson Theorem establishes that each factor price changes in the same direction and more than proportionally with the price of the output that uses that factor intensively (Yarbrough 2006). The derivation presented below will illustrate the positive relationship between relative prices and relative wages.[7]

Begin by assuming output of the two goods y_a and y_b can be summarized with linear homogenous, differentiable, positive and declining marginal product production functions:

$$\begin{aligned} y_a &= X^a(m_a, f_a) \\ y_b &= X^b(m_b, f_b) \end{aligned} \tag{1}$$

Where m_i and f_i are the quantities of male labor and female labor used in the production of good y_i.

We assume that the country has a fixed endowment of male labor (*M)* and female labor (*F)* and that these resources are fully employed in the production of goods y_a and y_b. That is,

$$\begin{aligned} m_a + m_b &= M \\ f_a + f_b &= F \end{aligned} \tag{2}$$

The production functions in (1) are characterized by constant returns, and can thus be expressed as:

$$X^j(tm_j, tf_j) = tX^j(m_j, f_j) \tag{3}$$

where $j = a, b$.

[7] The derivation of the Stolper Samuelson Theorem presented here is based on Steven M. Suranovic's mathematical derivation available online at: http://internationalecon.com/Trade/Tch115/T115-2.php

We can convert the production function (3) into a unit production function by assuming that $t = \frac{1}{y^j}$. It follows that:

$$1 = \frac{y_j}{y_j} = \frac{1}{y_j} X^j(m_j, f_j) \tag{4}$$

$$1 = X^j\left(\frac{m_j}{y_j}, \frac{f_j}{y_j}\right) = X^j(a_{mj}, a_{fj}) \tag{5}$$

where a_{mj} and a_{fj} represent the unit female labor and unit male labor requirements in the production of good *j*.

We can also write the resource constraints (2) in terms of the unit-factor requirements. The labor constraint becomes

$$\frac{m_a y_a}{y_a} + \frac{m_b y_b}{y_b} = M \tag{6}$$

$$a_{ma} y_a + a_{mb} y_b = M \tag{7}$$

Similarly, the female labor constraint can be written as

$$a_{fa} y_a + a_{fb} y_b = F \ . \tag{8}$$

The equalities (7) and (8) indicate the full employment condition

Assuming perfect competition in all markets, economic profit is always driven to zero. The zero profit condition in each industry implies:

$$a_{fa} w_f + a_{ma} w_m = p_a \tag{9}$$

$$a_{fb} w_f + a_{mb} w_m = p_b \tag{10}$$

where w_f is the female wage, w_m the male wage, p_a is the price per unit of good *a,* and p_b is the price per unit of good *b*. Notice that under the zero profit assumption (price equals marginal cost), the unit price of the good equals the payment to the factors of production.

Differentiating (9) with respect to p_a yields,

$$a_{fa}\frac{\partial w_f}{\partial p_a}+w_f\frac{\partial a_{fa}}{\partial p_a}+a_{ma}\frac{\partial w_m}{\partial p_a}+w_m\frac{\partial a_{ma}}{\partial p_a}=1. \tag{11}$$

If we rearrange the terms we obtain,

$$a_{fa}\frac{\partial w_f}{\partial p_a}+a_{ma}\frac{\partial w_m}{\partial p_a}=1-w_f\frac{\partial a_{fa}}{\partial p_a}-w_m\frac{\partial a_{ma}}{\partial p_a}\ . \tag{12}$$

Given that we hold the input combination constant regardless of a price change, we know that

$$w_f\frac{\partial a_{fa}}{\partial p_a}+w_m\frac{\partial a_{ma}}{\partial p_a}=0 \tag{13}$$

Hence (12) is reduced to

$$a_{fa}\frac{\partial w_f}{\partial p_a}+a_{ma}\frac{\partial w_m}{\partial p_a}=1 \tag{14}$$

If we differentiate (10) by p_a and use a similar procedure, we obtain

$$a_{fb}\frac{\partial w_f}{\partial p_a}+a_{mb}\frac{\partial w_m}{\partial p_a}=0 \tag{15}$$

We can solve for $\frac{\partial w_f}{\partial p_a}$ and $\frac{\partial w_m}{\partial p_a}$ by writing (14) and (15) into matrix form as follows:

$$\begin{bmatrix} a_{fa} & a_{ma} \\ a_{fb} & a_{mb} \end{bmatrix} * \begin{bmatrix} \frac{\partial w_f}{\partial p_a} \\ \frac{\partial w_m}{\partial p_a} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \tag{16}$$

This expression can now be solved using Cramer's Rule to get

$$\frac{\partial w_f}{\partial p_a} = \frac{a_{mb}}{a_{fa}a_{mb} - a_{fb}a_{ma}} \tag{17}$$

$$\frac{\partial w_m}{\partial p_a} = \frac{-a_{fb}}{a_{fa}a_{mb} - a_{fb}a_{ma}} \tag{18}$$

The signs of the derivatives in (17) and (18) depend on whether the denominators are positive or negative. The denominator is negative when

$$a_{fa}a_{mb} - a_{fb}a_{ma} < 0 \tag{19}$$

$$a_{fa}a_{mb} < a_{fb}a_{ma} \tag{20}$$

$$\frac{a_{mb}}{a_{fb}} < \frac{a_{ma}}{a_{fa}} \tag{21}$$

$$\frac{a_{mb}}{a_{fb}} - \frac{a_{ma}}{a_{fa}} < 0 \tag{22}$$

which is true if

$$\frac{M_b}{F_b} - \frac{M_a}{F_a} < 0 \quad \text{or} \quad \frac{M_a}{F_a} > \frac{M_b}{F_b} \tag{23}$$

Notice that the second expression in (23) indicates that good *a* is male intensive and good *b* is female intensive.

If we return to expression (17) and (18), assuming that good *a* is male intensive we can say that

$$\frac{\partial w_f}{\partial p_a} < 0 \text{ and } \frac{\partial w_m}{\partial p_a} > 0 \tag{24}$$

Equation (24) implies that if the price of *a* increases, the equilibrium wage for female workers w_f will fall and the equilibrium wage for male workers w_m will increase. The same relationship will be derived with respect to the price of *b*.

$$\frac{\partial w_f}{\partial p_b} > 0 \text{ and } \frac{\partial w_m}{\partial p_b} < 0 \tag{25}$$

We see that if the price of a good rises (falls) then the price of the factor used intensively in that industry will also rise (fall) while the price of the other factor will fall (rise) (Stolper and Samuelson 1941).

Figure 2 describes a possible scenario under the assumptions of our model. If country X has a comparative advantage in female intensive goods then production will specialize in female intensive goods. As the country produces more female intensive goods and less male intensive goods, the opportunity cost or relative price of producing female intensive goods will increase.[8] The expansion of the female-intensive sector will increase the demand for female labor from D_f (1) to D_f (2). Given that there is a fixed supply of female workers at F, the wage will increase from W_f (1) to W_f (2). Assuming full employment, the expansion of the female intensive sector implies that the male-intensive sector is contracting. As a result the demand of male labor falls from D_m (1) to D_m (2) and

[8] This follows if we assume there are increasing costs of production.

the male wage falls from W_m (1) to W_m (2). Notice that an increase in the relative price of the female intensive good has increased the female relative wage (W_f/W_m) hence this will reduce the gender wage gap. The Stolper Samuelson Theorem is a long run, general equilibrium result; hence if the relative price of female intensive goods rises we expect relative wages of women to increase across all sectors of the economy.

III. Empirical Strategy and Data

We proceed with four separate estimation stages. First, we estimate the elasticity of factor substitution between male and female labor in order to empirically evaluate whether or not they are perfect substitutes. Second, we estimate the relative female wage in the manufacturing sector and across all sectors of the economy using established techniques from labor economics. Third, we determine the relative price of female intensive foods and track it over time. Lastly, we formally test whether relative prices of female-intensive goods explain the relative female wage. The following subsections include a description of the methodology and data used for each estimation stage.

1. Elasticity of Factor Substitution

The elasticity of factor substitution indicates the ease with which a certain level of production can be maintained by substituting between two factors. Hicks (1932) developed the concept of elasticity of substitution between two inputs as a percentage change in the input ratio in response to a percentage change in the marginal rate of technical substitution.

$$\sigma_{FM} = \frac{\Delta(F/M)/(F/M)}{\Delta(MRTS_{FM})/(MRTS_{FM})} \tag{26}$$

The higher the elasticity, the easier it is to substitute one factor for the other. Also, there are two limiting cases. An elasticity of 0 indicates that two factors are perfect complements while ∞ denotes perfect substitutes.

Allen (1938) introduced the Allen Elasticity of Substitution (AES) as a measure of factor substitution. Estimating the AES requires estimating parameters using the translog production function, which is a second order Taylor series expansion. The Translog production function for three inputs is given by

$$y = \alpha + \beta_f f + \beta_m m + \beta_k k + \beta_{fm} fm + \beta_{fk} fk + \beta_{mk} mk + \beta_{ff} f^2 + \beta_{mm} m^2 + \beta_{kk} k^2 + \varepsilon^{9} \tag{27}$$

where the constant α and the βs are the parameters to be estimated, *y* is value added as a measure of output, k is capital, f is female labor, m is male labor and ε is an error term. The estimated parameters are then used to calculate the first and second derivatives of the Translog function which are given by (Mohammad and Zhang 2008)

$$f_f = \frac{1}{f}\left[\beta_f + 2\beta_{ff} f + \beta_{fm} m + \beta_{fk} k\right], \quad f_m = \frac{1}{m}\left[\beta_m + 2\beta_{mm} m + \beta_{fm} f + \beta_{mk} k\right], \tag{28}$$

$$f_k = \frac{1}{k}\left[\beta_k + 2\beta_{kk} k + \beta_{mk} m + \beta_{fk} f\right], \quad f_{ff} = -\frac{1}{f^2}\left[\beta_f + 2\beta_{ff} f - 2\beta_{ff} + \beta_{fm} m + \beta_{fk} k\right]$$

$$f_{mm} = -\frac{1}{m^2}\left[\beta_m + 2\beta_{mm} m - 2\beta_{mm} + \beta_{fm} f + \beta_{mk} k\right],$$

$$f_{kk} = -\frac{1}{k^2}\left[\beta_k + 2\beta_{kk} k - 2\beta_{kk} + \beta_{fk} f + \beta_{mk} m\right]$$

$$f_{fm} = \frac{\beta_{fm}}{fm}, \quad f_{fk} = \frac{\beta_{fk}}{fk}, \quad f_{mk} = \frac{\beta_{mk}}{mk}$$

[9] We use capital letter for quantities of Y, K, F, and M, and lower case to denote logs of these quantities.

Finally the Allen Elasticity of Substitution between female and male workers can be calculated by applying the formula (Allen 1938):

$$\sigma_{fm} = \frac{-f_f f_m (f_f F + f_m M)}{FM(f_{ff} f_m^{\ 2} - 2 f_f f_m f_{fm} + f_{mm} f_f^{\ 2})} \tag{29}$$

The first and second derivatives and the elasticities are evaluated at the geometric means of each of the inputs.

For this estimation stage we used the Industrial Census Data from Mexico's National Institute of Geography and Statistics (INEGI). Data were available for the years 1989, 1994 and 1999. For each year, the census includes production, employment, capital, and wage data for over 5,000 manufacturing firms. **Tables 1, 2 and 3** provide summary statistics for the three years of data.

2. **Relative Wages**

The manufacturing and economy-wide gender wage differential can be estimated by using a Mincerian wage equation. The Mincerian wage equation is widely used in labor economics as a way to predict workers' wages.

$$\begin{aligned} \ln wage_{kt} &= \alpha_0 + \beta_1 female_{kt} + \beta_2 age_{kt} + \beta_3 age_{kt}^2 + \beta_4 education_{kt} \\ &+ \sum_o^n \gamma_o occupation_{ot} + \sum_i^n \delta_i industry_{it} + \varepsilon_{kt} \end{aligned} \tag{30}$$

This equation decomposes the log wage for an individual k at time t as a function of observable characteristics. There are many factors affecting wages, some of which are difficult to measure such as differences in workers abilities or gender discrimination. The female dummy coefficient β_1 in equation (30) is the female wage differential holding other demographic characteristics constant.

For this stage, we use household employment surveys from Mexico's National Institute of Geography and Statistics (INEGI). Quarterly data are available in three waves of surveys: The National Survey on Urban Employment (ENEU) (1988 to 2002), The National Survey on Employment (ENE) (2003 to 2004) and The National Survey on Employment and Occupation (ENOE) (2005 to the second quarter of 2010). In total we obtain 90 cross sections across 23 years.

The total sample size in the three surveys ranges between 120,000 to 440,000 individuals per quarter. The ENEU includes only urban areas while the ENE and ENOE also incorporates rural areas. The geographical coverage differs through time; therefore we reduce the sample to the 16 cities included in the first quarter of 1988[10]. For the estimation of Mincerian wage equation, we included individuals aged 16 to 65 and eliminated individuals who work but do not receive a wage and those that receive a wage without working. In the end we obtained two subsamples: manufacturing and all sectors in the economy. On average there are 23,000 individuals per quarter in manufacturing and 81,600 per quarter for all sectors in the economy.

Figures 3 (a and **b)** show time trends for these for economy-wide and manufacturing subsamples. Notice that the sample size in both trends drops after 2003 given that the ENE and ENOE surveys also include rural areas which reduced the number of

[10] Cities: México City, Guadalajara, Monterrey, Puebla, León, San Luis Potosí, Tampico, Torreón, Chihuahua, Orizaba, Veracruz, Mérida, Ciudad Juárez, Nuevo Laredo, Matamoros, Tijuana.

households surveyed in each city. **Table 4** provides summary statistics for the household surveys.

3. Relative Prices

Relative prices are defined as the production-weighted ratio of the output prices of female and male intensive industries. We calculate price indices for both industries by using production and volume data at the 8-digit level[11] from the Monthly Industrial Survey (EIM). These data are available from 1988-2010 and are also provided by INEGI. The EIM contains production values and volumes for over 900 identifiable products (averaging 25 products per four-digit industry).

To construct the price indices we grouped the production data into female intensive and male intensive industries. We were able to identify two female intensive industries in the household surveys (ENEU, ENE, ENOE) by calculating the female to male employment ratio in each industry. Textiles and apparel were the industries that reported a ratio that was consistently higher than one for the 23 years being analyzed. **Figures 4 (a** and **b)** show the female factor intensity of these industries over time. The trends indicate that only Apparel has remained female intensive during the whole period of study while Textiles shifted between male and female intensive several times. For this reason we will first consider only apparel as female intensive and incorporate Textiles as a robustness check.

[11] 8-digit level quantities and production values are reported in for general categories such as socks, shirts, etc.

Using this classification, we calculated the price index for male and female intensive industries separately using the average of the Laspeyres and Paasche price indices. Finally, in order to get the relative price of female-intensive goods we calculate the ratio between the output price indices of female and male-intensive goods. **Figures 5 (a** and **b)** show the monthly movement in the price index for female intensive goods (apparel) and male intensive goods (all other goods except apparel goods). By taking the ratio between the two previous series we calculated the relative price of female intensive goods **(Figure 6 (a** and **b))**. The relative price of apparel will be used in the main analysis of this paper. As a robustness check we also calculated the relative price of textiles and apparel. Summary statistics for the price data are provided in **Table 5**.

4. Relative Prices and Relative Wages

We can now derive the guiding equation that will be used to test the Stolper Samuelson Theorem. Equation (31) shows that the wage differential (W_f/W_m)[12] is a function of the relative price of female intensive goods (P_f/P_m). If the Stolper-Samuelson Theorem holds in the long run, we expect a significant positive coefficient for α_1. One problem of this approach is determining the appropriate time horizon for the long run. Robertson (2004) suggests that the Stolper-Samuelson effects begin to emerge in three to five years. [13] For this reason relative prices are lagged by *k* periods as shown in equation (31).

[12] (W_f/W_m) = 1- ($\beta_1 * 100$), where β_1 is the coefficient for the female dummy in equation (28).

[13] Mussa (1971) shows that the Stolper-Samuelson Theorem predictions do not hold in the short run due to imperfect factor mobility. If we assume that in the short run women are relatively immobile due to social norms, a change in the relative price of female intensive goods will affect industry specific wages in the short run (Robertson 2010).

$$\ln\left(\frac{W_f}{W_m}\right)_t = \alpha_0 + \alpha_1 \ln\left(\frac{P_f}{P_m}\right)_{t-k} + \alpha_2 \ln\left(\frac{LFP_f}{LFP_m}\right)_t + \varepsilon_t \qquad (31)$$

We also control for the relative working labor force participation (LFP) of women (LFP_f/LFP_m). The Stolper Samuelson Theorem assumes there is a fixed supply of factors, however we observe that in the last 20 years there has been a considerable increase in female LFP and to a lesser extent in male LFP as well (**Figures 7 (a** and **b))**. We expect that this supply shock will have a negative effect on female relative wages.

IV. Results

1. **Elasticity of Factor Substitution**

We estimated the Translog Production function (equation 27) for each of the three years of data. **Table 6** contains the results. **Table 7** uses the coefficients estimates from **Table 6** to calculate the elasticity of substitution for each of the 3 factors pairs. Our elasticity estimates are much lower than those obtained in other studies. Using a two-input model, Schaasfma's (1978)[14] estimates an elasticity of substitution between capital and labor of 0.42. Symmons (1985) finds an elasticity of substitution of 2.40.[15] As shown in **Table 7** the highest elasticity of substitution between female and male workers (σ_{fm}) for all three years is 0.175. This indicates that male and female workers are imperfect substitutes and therefore can be treated as two different factors of production.

[15] Both studies use manufacturing employment as a measure of labor. Other studies incorporate worker hours instead.

2. Relative Wages

Sample selection bias is the main estimation issue when estimating Mincerian wage equations. Observed female wages are not representative of the total female population. Females who are employed will tend to have higher wages than those who are not in the labor force (which may be why they are not in the labor force in the first place). Hence it becomes necessary to correct for selection bias. To address this issue, we employ the two-step Heckman approach in which a selection (probit) equation is estimated for men and women separately. These two regressions include the same variables as in (30) except for the female dummy variable. In addition we use marriage as the selection variable. The first estimation stage generates a selection correction variable (the "inverse of the Mills Ratio") for women and for men. We then estimate the Mincerian wage equation (30) by including the selection correction variable (Heckman 1979).

We estimate wage equations for each quarter from 1988 to 2010 in order to determine the relative female wage in manufacturing[16] and across all economic sectors. **Figure 8** shows the estimated coefficients for the female wage differential in manufacturing. [17] Between 1988 and 2010, women in the manufacturing sector earned on average 16.06% less than men. We observe that the gender wage gap increased from 12.7 % to 17.4% during the years following the GATT (1988-1991). Between 1991 and 1993 we observe a reduction in the gender wage gap of 5.78 percentage points. In the years following NAFTA, the gender wage gap increased from 13.6 % in 1994 to 18.04% in 2000. After 2000 it has remained relatively constant at around 18.5%.

[16] **Table 8** the regression results only for the first quarter of 1988.
[17] The coefficient show the percent difference in wages of women compared to men. A coefficient of -0.10 indicates that women earn 10% less than men controlling for observable characteristics.

As far as the economy-wide female wage differential (**Figure 9**) we observe it decreases from 22.72% in 1988 to 10.67% in 1995. Between 1995 and 2001 there is a slight increase in the gender wage gap of about 5.76 percentage points. After 2001 we only observe a slight improvement in the gender wage gap. A comparison between the economy wide and manufacturing female wage differential (**Figure 10**), suggests that there was a positive pre-NAFTA and a negative post-NAFTA effect on gender wage inequality. Both trends show that the effect eventually dissipated after 2001.

3. Relative Prices and Relative Wages

In this final estimation stage we determine the effect of relative prices of female intensive goods on relative female wages in manufacturing and across all sectors in the economy. **Figure 11** shows that the relative female wage in manufacturing seems to respond to changes in relative apparel prices. We can observe that there is a similar pattern between the economy-wide relative female wages and the relative price of apparel (F**igure 12).**

As discussed in the empirical section, we expect that relative prices will have an effect on relative wages within 3 to 5 years. Our regressions on relative female wages include a lagged term for the relative price of female intensive goods and a non-lagged term for the relative female labor force participation rate. Using quarterly data, I tested multiple specifications using one through 20 quarterly lags of relative prices. This allows us to identify the time window in which relative prices have the strongest effect on relative female wages. All the results reported for this stage are adjusted for serial correlation using the Cochrane-Orcutt estimator.

First, I estimate the effect of the relative price of apparel on the relative female wage in manufacturing. **Figure 13** shows the estimated coefficients for relative prices and the corresponding t-statistics obtained in each of the lagged models. We observe that the effect of relative prices on relative wages peaks at 16 quarters (four years). The coefficient for the relative price of apparel was significant at the 5% level with a magnitude less than one.[18] **Table 9** shows the complete regression results for the 16-quarter lag model (L.16). The sign of the coefficient for the relative female labor participation rate (LFP) was negative as expected and significant at the 1% level.

The Stolper Samuelson theorem is general equilibrium result therefore relative apparel prices should have an effect on the economy-wide female relative wage. Regression results indicate that the effect of relative apparel prices on the economy-wide relative wages peaks once again at four years (**Figure 14)**. Nevertheless the coefficient obtained was significant only at the 10% level. The relative LFP variable was also statistically insignificant (**Table 10**).

Robustness

As a robustness check we run the same estimations as in the previous section but instead we use the relative price index that incorporates both textiles and apparel as female

[18] The magnitude of the coefficient provides no evidence for the magnification effect of prices on wages.

intensive goods. First we test the effect of relative prices on relative wages in manufacturing. As shown in **Figure 15,** the effect of relative prices on relative wages peaks at four years. The coefficient for the relative price of textiles and apparel has a magnitude of 0.12 and is statistically significant at the 1% level. **Table 11** shows that the coefficient for relative LFP is negative and significant at the 1% level.

Finally we estimate the effect of relative prices on the economy wide relative wages. As shown in **Figure 16,** the effect of relative prices on relative wages peaks at four years. The coefficient for the relative price of textiles and apparel has a magnitude of 0.05 and is statistically significant at the 5% level (**Table 12**). This result provides some evidence on the general equilibrium effect of the Stolper Samuelson Theorem. The relative LFP coefficient was statistically insignificant.

V. Conclusions

This study explores the determinants of gender wage inequality by studying the relationship between relative output price and relative factor rewards. The results are indicative of a positive and statistically significant relationship between relative prices of female intensive goods and relative female wages. Our multiple lagged models show that the effect of relative prices on relative wages peaks at 4 years. This time frame applies for both relative female wages in manufacturing and across all sectors in the economy. The estimation coefficients indicate that a percent increase in relative prices will increase relative female wages by about .10% in the manufacturing sector and by 0.05% economy wide.

Some of the future extensions of this work will involve testing the relationship between the price of US apparel and textiles imports from Mexico and female relative wages in Mexico. This price series will provide a more direct impact of trade given that it involves only tradable goods. In addition we will revise the female intensity classification of industries by using the Mexican Industrial census rather than the household surveys (ENEU, ENE, and ENOE). Female and male employment in the Industrial Census is provided by the firms themselves; hence we can avoid potential employment reporting bias from the household surveys.

Future research should apply this framework to studying the impact of trade on the gender wage gap in other developing countries where the apparel and textile industries employ a large part of the female labor force in manufacturing.

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Table 1. Summary Statistics Industrial Census Data (Year 1989)

Variable	Obs	Mean	Std. Dev.	Min	Max
Value Added	5036	13680.22	60923.86	-7448.20	1522599.00
Female Labor	4890	126.67	526.83	0.00	19818.00
Male Labor	4890	346.48	1028.43	0.00	23195.00
Gross Fixed Capital Formation	5036	1765.37	20500.43	-3253.30	919418.00
Log Value Added	4950	6.60	2.84	-2.30	14.24
Log Female Labor	3920	3.21	1.94	0.00	9.89
Log Male Labor	4420	4.20	2.06	0.00	10.05
Log Fixed Capital Formation	3962	5.04	2.48	-2.30	13.73

Note: Value added and Fixed capital formation are expressed in current Mexican Pesos (MXN)

Table 2. Summary Statistics Industrial Census Data (Year 1994)

Variable	Obs	Mean	Std. Dev.	Min	Max
Value Added	5664	32736.79	140212.80	-90762.10	3978287.00
Female Labor	5517	155.10	639.57	0.00	24802.00
Male Labor	5517	358.76	1034.77	0.00	27483.00
Gross Fixed Capital Formation	5664	3308.61	19247.68	-28203.20	735054.80
Log Value Added	5618	7.62	2.86	-2.30	15.20
Log Female Labor	4501	3.31	2.01	0.00	10.12
Log Male Labor	4927	4.25	2.08	0.00	10.22
Log Fixed Capital Formation	4103	5.53	2.83	-2.30	13.51

Note: Value added and Fixed capital formation are expressed in current Mexican Pesos (MXN)

Table 3. Summary Statistics Industrial Census Data (Year 1999)

Variable	Obs	Mean	Std. Dev.	Min	Max
Value Added	5992	96629.94	424622.40	-5109944.00	13300000.00
Female Labor	5864	217.56	971.34	0.00	41221.00
Male Labor	5864	422.43	1363.68	0.00	53104.00
Gross Fixed Capital Formation	5992	14900.34	135442.30	-1036109.00	7830988.00
Log Value Added	5714	8.53	3.04	0.00	16.40
Log Female Labor	4809	3.40	2.12	0.00	10.63
Log Male Labor	5261	4.29	2.18	0.00	10.88
Log Fixed Capital Formation	4109	6.84	2.91	0.00	15.87

Note: Value added and Fixed capital formation are expressed in current Mexican Pesos (MXN)

Table 4. Household Surveys Summary Statistics
(Economy-Wide Sample 1988-2010)

Variable	Mean	Std. Dev.	Min	Max
Economy-Wide Sample Size	81602.38	15552.73	49222	100376
Age	34.34	13.30	16	65
Age2	1356.88	1018.75	4225	256
Years of Education	8.89	4.22	0	20
Nominal Hourly Wage (MXN Pesos)	10.46	22.79	0	2442.50
Real Hourly Wage (MXN Pesos)	14.43	35.96	0	4842.89
Real Hourly Wage (USD)	2.61	7.28	0	1120.23
Log Hourly Wage (MXN Pesos)	2.30	0.73	-2.64	7.49
% Males in Sample	46.43	0.61	45.37	47.66
% Females in Sample	53.57	0.61	52.34	54.63
% of working population in manufacturing	24.92	2.25	20.39	28.53
% of female manufacturing workers in apparel	17.13	2.15	11.59	19.96
% of female manufacturing workers in textiles	2.06	0.74	0.91	4.16
% of female workers in apparel	3.83	0.86	2.10	5.37
% of female workers in textiles	0.45	0.18	0.20	0.98
%Singles	48.94	2.30	46.54	55.43
%Married	51.06	2.30	44.57	53.46

Notes: Summary statistics were calculated based on 90 quarters of data.
Source: ENEU(1988-2002), ENE(2003-2004), ENOE(2005-2010)

Table 5. Price Data Summary Statistics

Variable	Months	Mean	Std. Dev.	Min	Max
Price Male Intensive Goods (Excluding Apparel)	274	0.67156	0.3742	0.1308	1.343
Price Male Intensive Goods (Excluding Apparel and Textiles)	274	0.67160	0.3744	0.1307	1.344
Price Female Intensive Goods (Apparel)	274	0.666	0.34	0.14	1.27
Price Female Intensive Goods (Apparel and Textiles)	274	0.672	0.33	0.15	1.23
Relative Price of Apparel	274	1.03	0.10	0.84	1.42
Relative Price of Textiles and Apparel	274	1.06	0.13	0.84	1.49

Notes: Relative Price of Apparel is the ratio between the price of the Apparel and all other goods. Relative Price of Textiles and apparel is the ratio between the price of textiles and apparel and all other goods.

Table 6. Translog Regression Results

Variable	Year 1989	1994	1999
LnF	0.437	0.351	0.34
	(11.39)**	(11.52)**	(9.49)**
LnM	0.492	0.474	0.511
	(9.54)**	(11.81)**	(9.58)**
LnK	0.023	0.023	0.138
	-0.71	-0.81	(4.34)**
LnF^2	0.023	0.035	0.041
	(2.95)**	(5.66)**	(5.69)**
LnM^2	0.052	0.068	0.083
	(4.08)**	(6.57)**	(6.35)**
LnK^2	0.019	0.026	0.038
	(3.72)**	(7.09)**	(9.47)**
LnF*LnM	-0.072	-0.084	-0.078
	(4.22)**	(6.52)**	(5.01)**
LnF*LnK	-0.018	-0.009	-0.025
	(2.01)*	-1.48	(2.71)**
LnM*LnK	0.007	-0.022	-0.056
	-0.53	-1.93	(4.71)**
Constant	2.957	4.337	4.437
	(28.38)**	(52.08)**	(45.98)**
Observations	3335	3582	3616
R-squared	0.82	0.85	0.85

Robust t statistics in parentheses

* significant at 5%; ** significant at 1%

Table 7. Elasticities of Factor Substitution

Elasticity	Year 1989	1994	1999
σ_{fm}	0.0485	0.0602	0.175
σ_{fk}	0.0265	0.0256	0.0535
σ_{mk}	0.007	0.007	0.008

Table 8. Heckman Wage Equation Regression Results Year 1988 Quarter 1

Variable	
Female	-0.09
	(-7.00)**
Age	0.04
	(15.67)**
Age^2	0.00
	(-12.49)**
Years of Education	0.03
	(24.92)**
Mills	-0.18
	(-3.1)**
Constant	-0.41
	(-1.25)
Occupation F-Test	Prob > chi2 = 0.0000
Industry F-Test	Prob > chi2 = 0.0000
Observations	13177

Absolute value of z statistics in parentheses

* Significant at 5%; ** significant at 1%

Table 9. Regression Results

Variable	Relative Wages in Manufacturing
16-Quarter Lagged Relative Prices (Apparel)	0.082
	(2.03)*
Relative Female Labor Force Participation	-0.291
	(5.64)**
Constant	-0.365
	(11.23)**
Observations	71
R-squared	0.37

Absolute value of t statistics in parentheses

* significant at 5%; ** significant at 1%

Standard Errors adjusted for serial correlation using the Cochrane-Orcutt Estimator

All variables are expressed in natural logs.

(Dependent Variable: Female Relative Wage in Manufacturing)

Table 10. Regression Results

Variable	Relative Wages Economy Wide
16-Quarter Lagged Relative Prices (Apparel)	0.047
	(1.78)
Relative Female Labor Force Participation	-0.057
	(1.05)
Constant	-0.182
	(5.42)**
Observations	73
R-squared	0.06

Absolute value of t statistics in parentheses

* significant at 5%; ** significant at 1%

Standard Errors adjusted for serial correlation using the Cochrane-Orcutt Estimator

All variables are expressed in natural logs.

(Dependent Variable: Economy-Wide Female Relative Wage)

Table 11. Regression Results

Variable	Relative Wages in Manufacturing
16-Quarter Lagged Relative Prices (Apparel and Textiles)	0.119
	(3.29)**
Relative Female Labor Force Participation	-0.233
	(4.83)**
Constant	-0.335
	(11.45)**
Observations	71
R-squared	0.48

Absolute value of t statistics in parentheses

* significant at 5%; ** significant at 1%

Standard Errors adjusted for serial correlation using the Cochrane-Orcutt Estimator

All variables are expressed in natural logs.

(Dependent Variable: Female Relative Wage in Manufacturing)

Table 12. Regression Results

Variable	Relative Wages Economy Wide
16-Quarter Lagged Relative Prices (Apparel and Textiles)	0.055
	(2.07)*
Relative Female Labor Force Participation	-0.034
	(0.66)
Constant	-0.171
	(5.38)**
Observations	73
R-squared	0.07

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%
Standard Errors adjusted for serial correlation using the Cochrane-Orcutt Estimator
All variables are expressed in natural logs.
(Dependent Variable: Economy-Wide Female Relative Wage)

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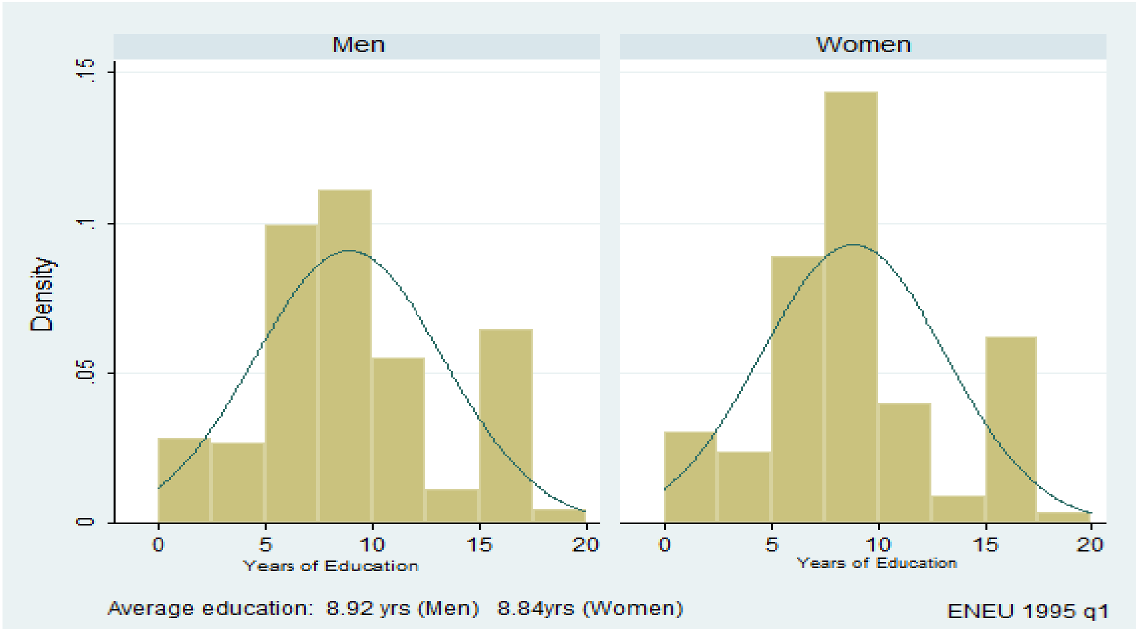

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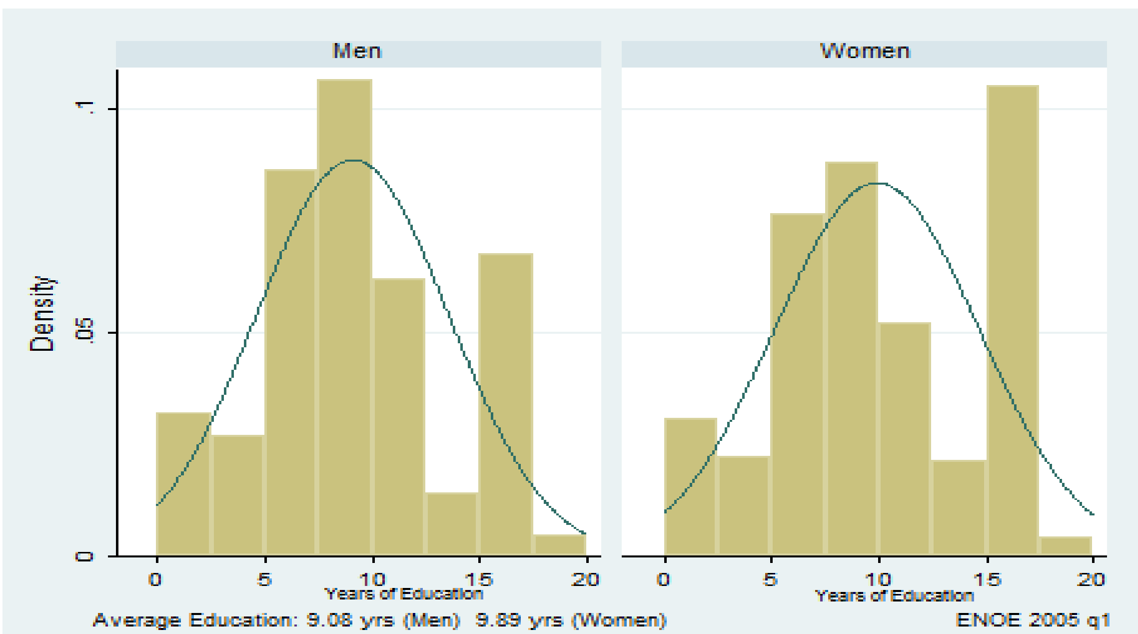

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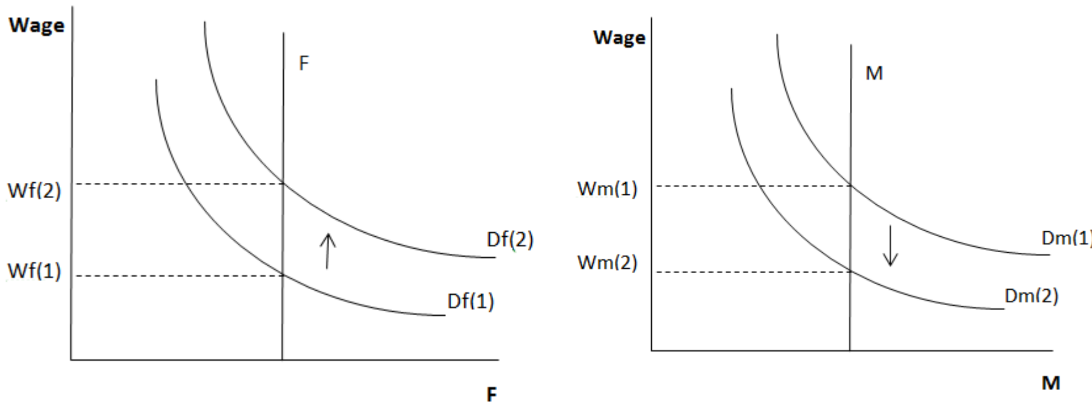

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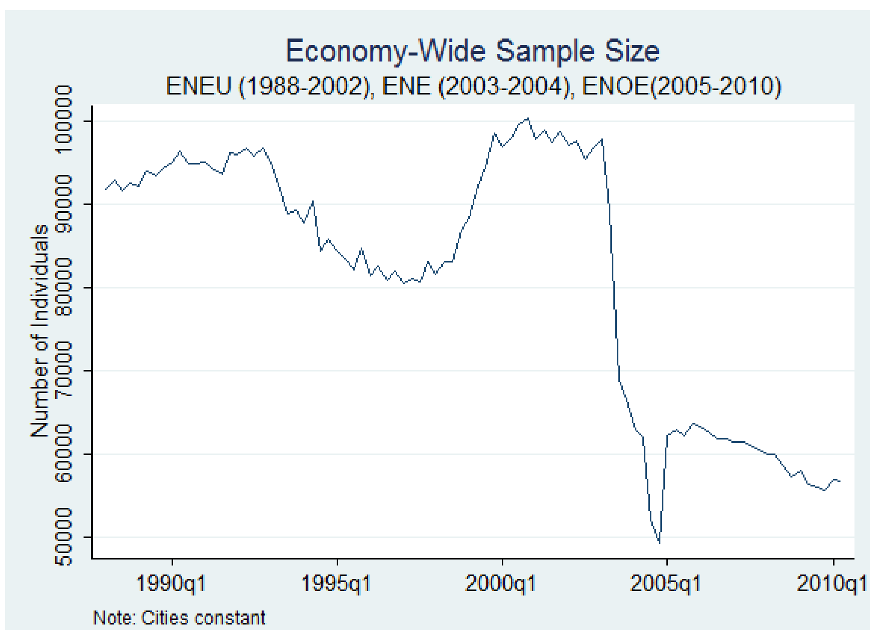

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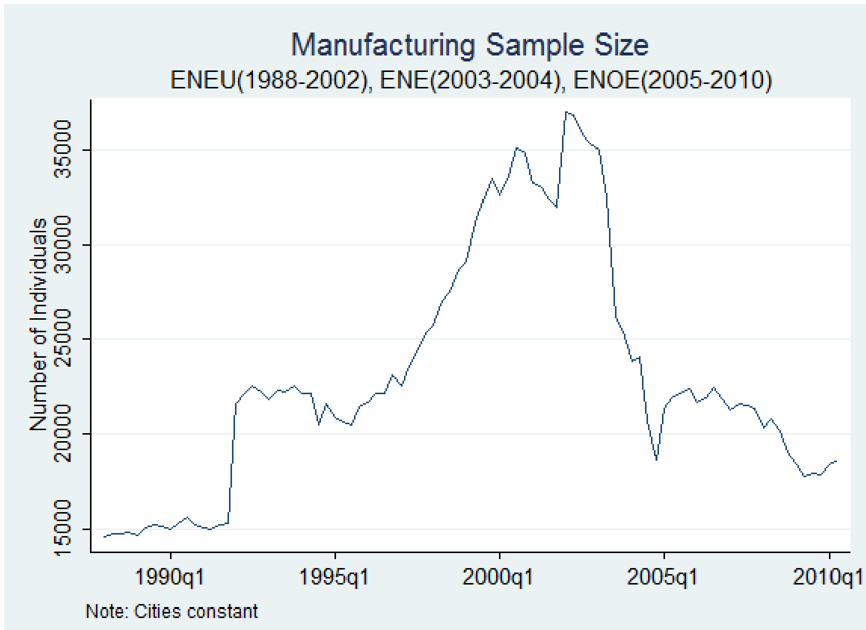

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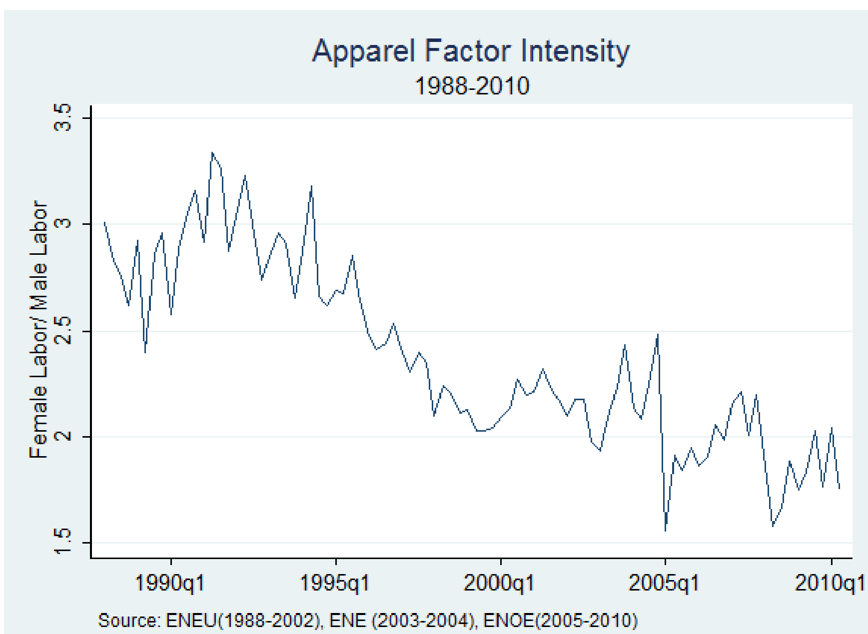

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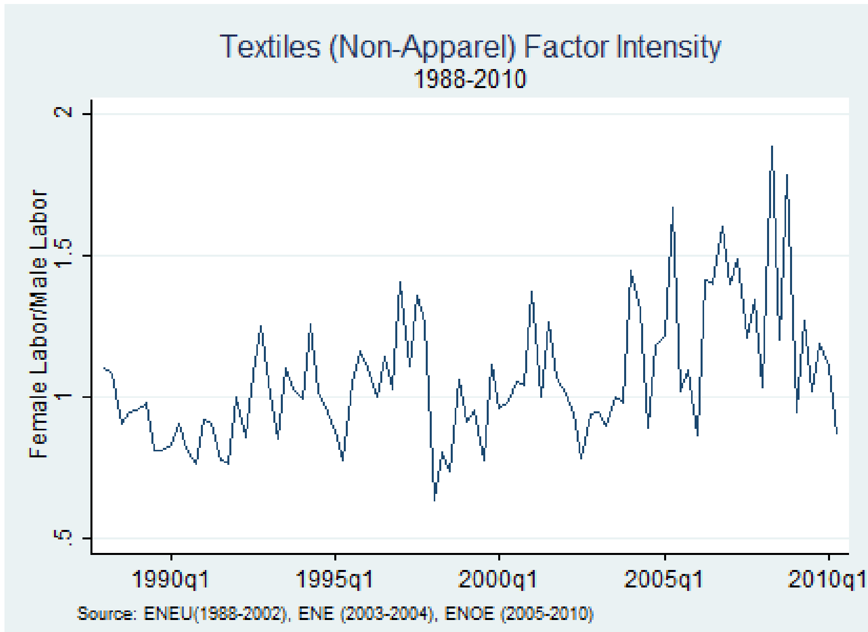

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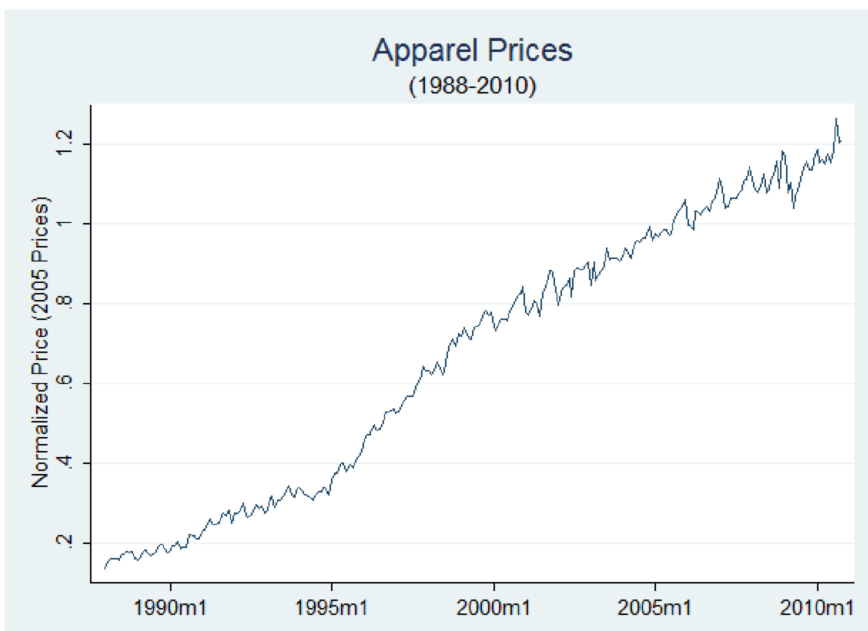

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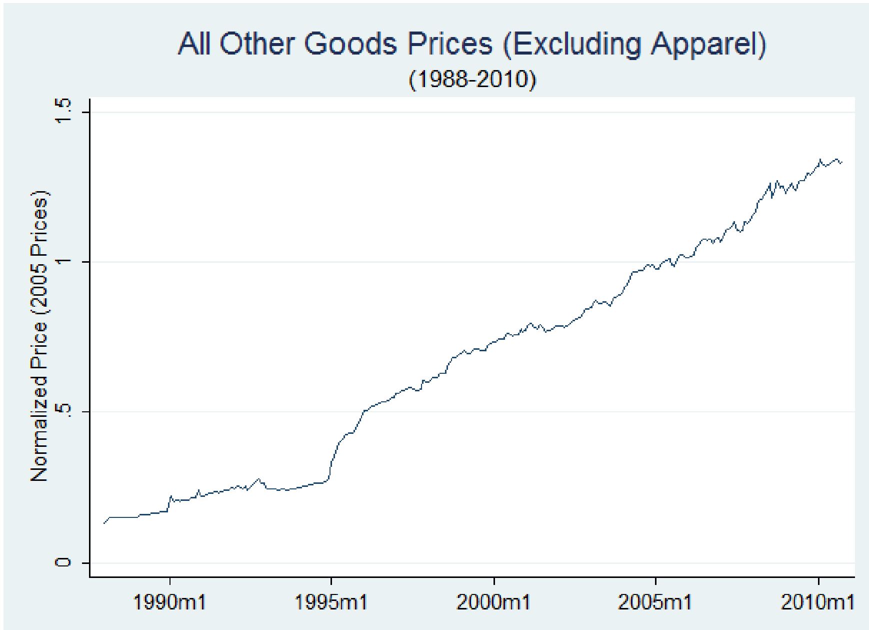

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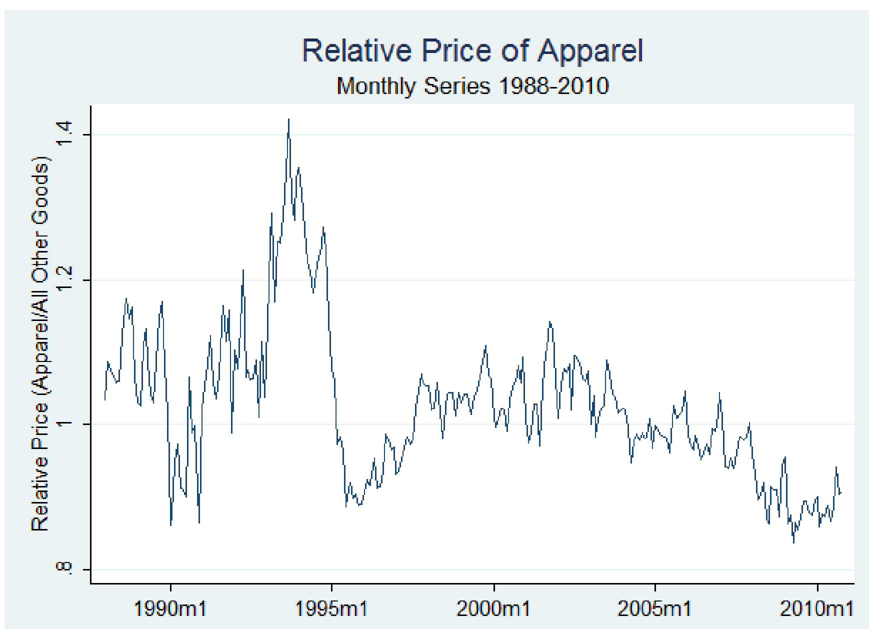

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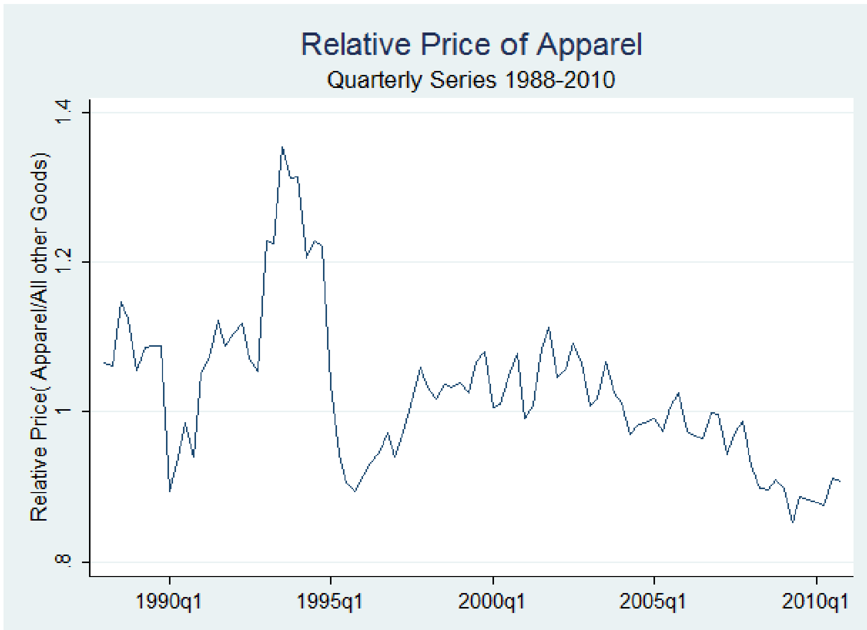

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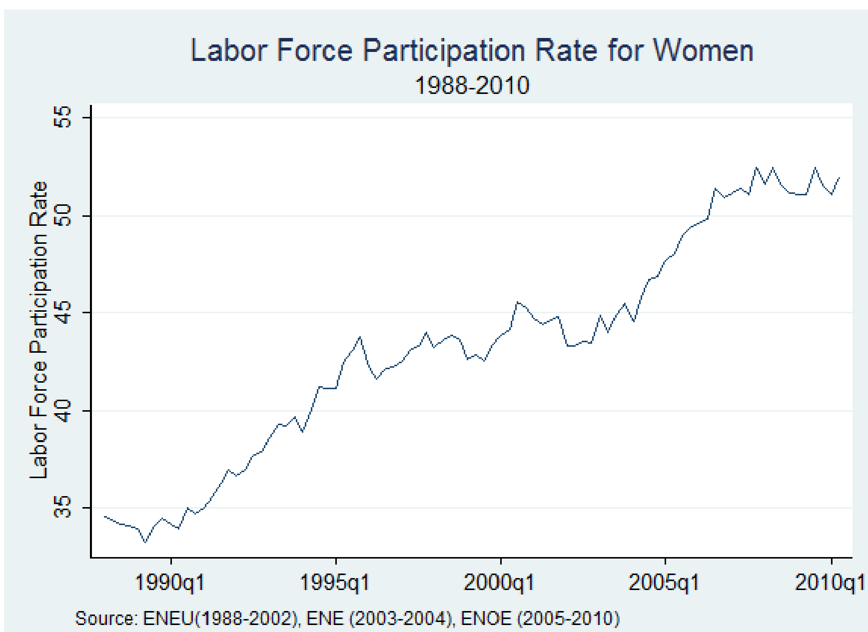

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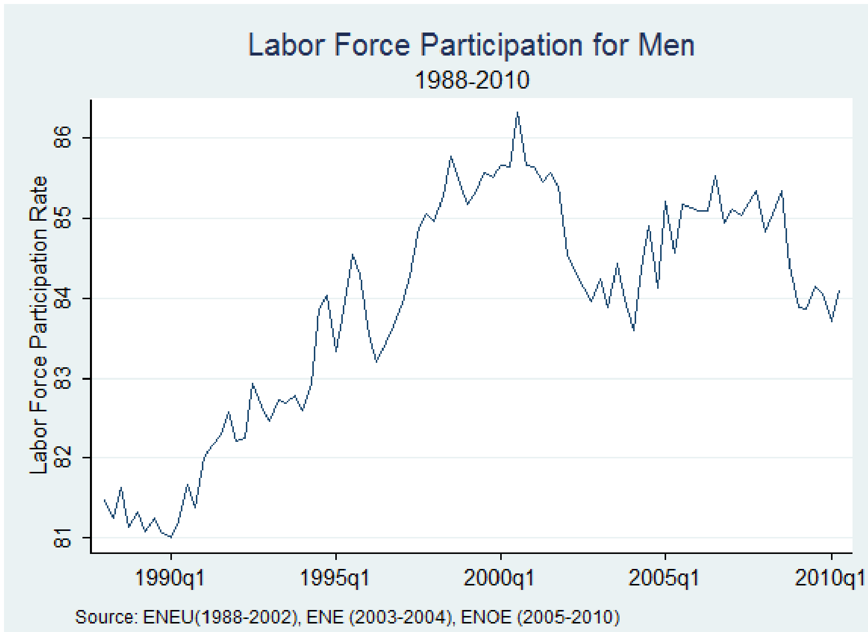

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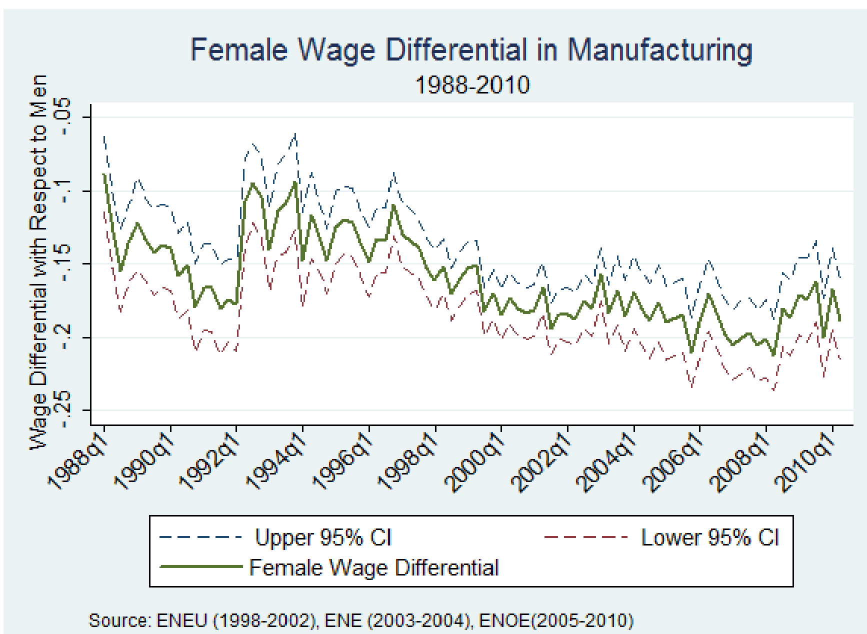

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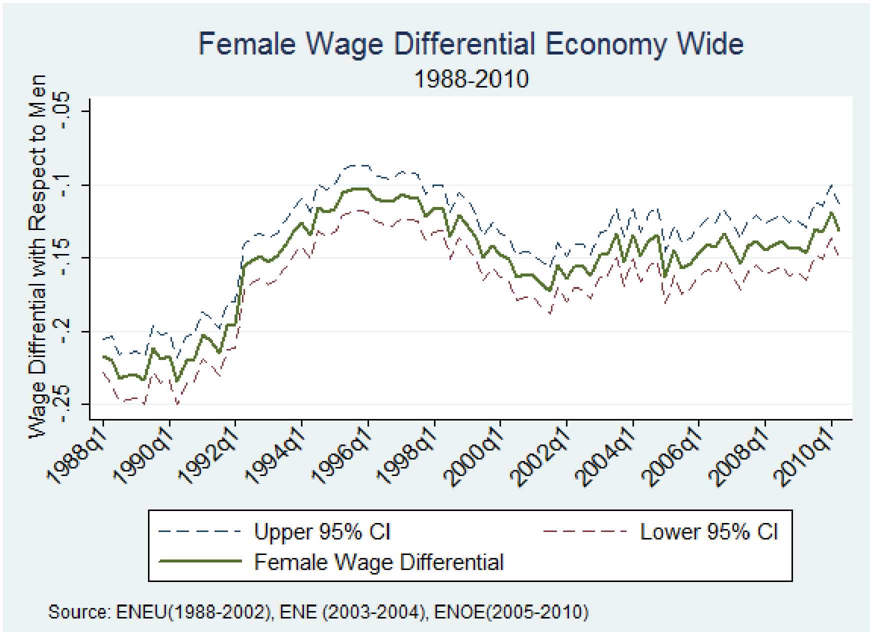

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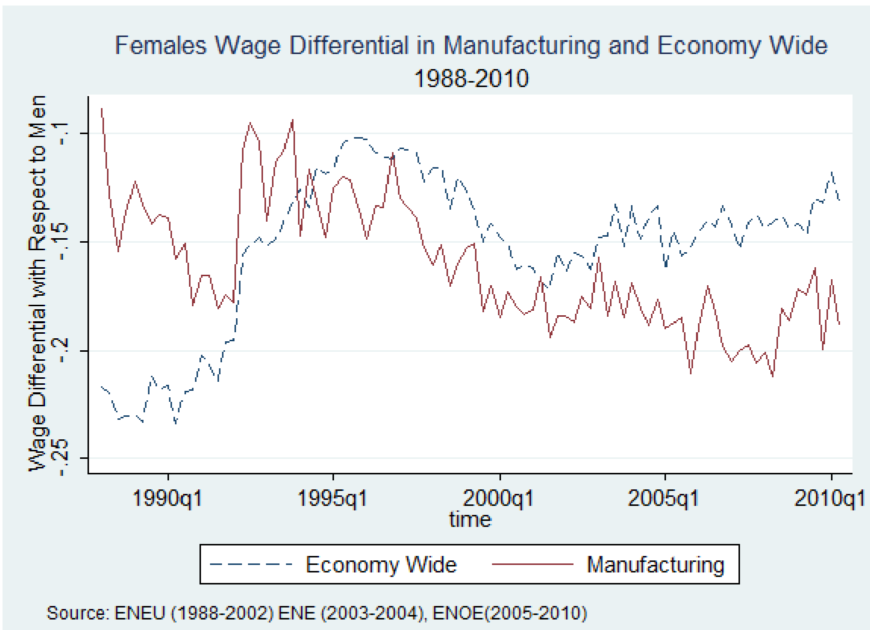

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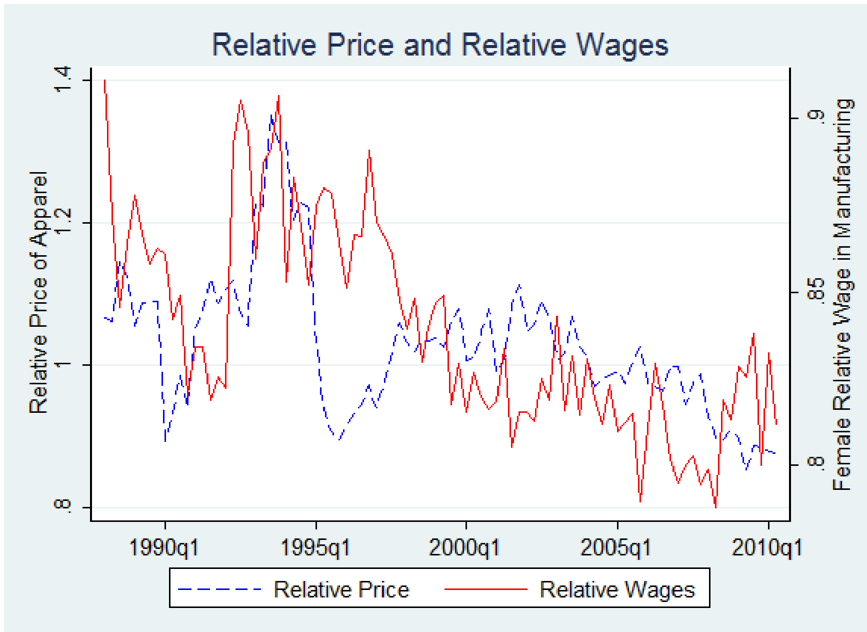

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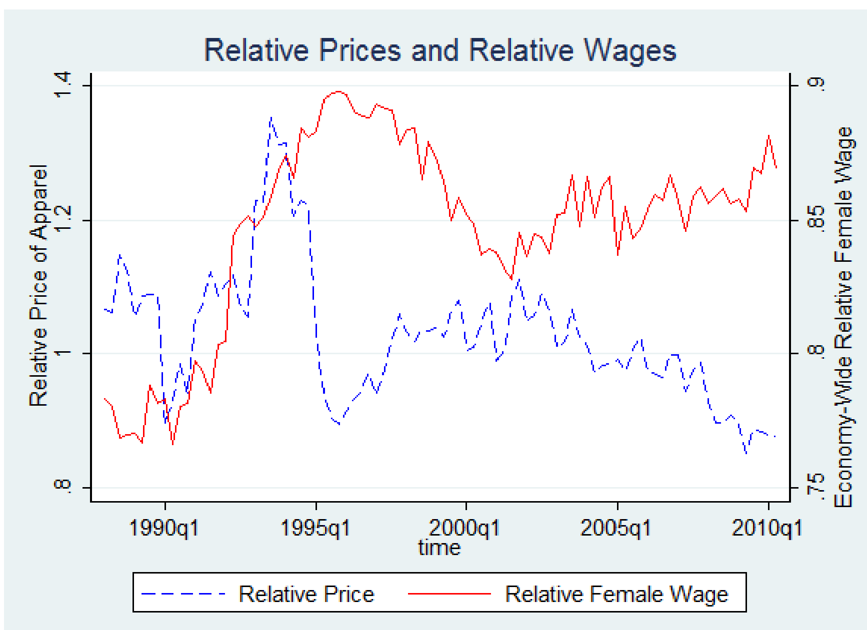
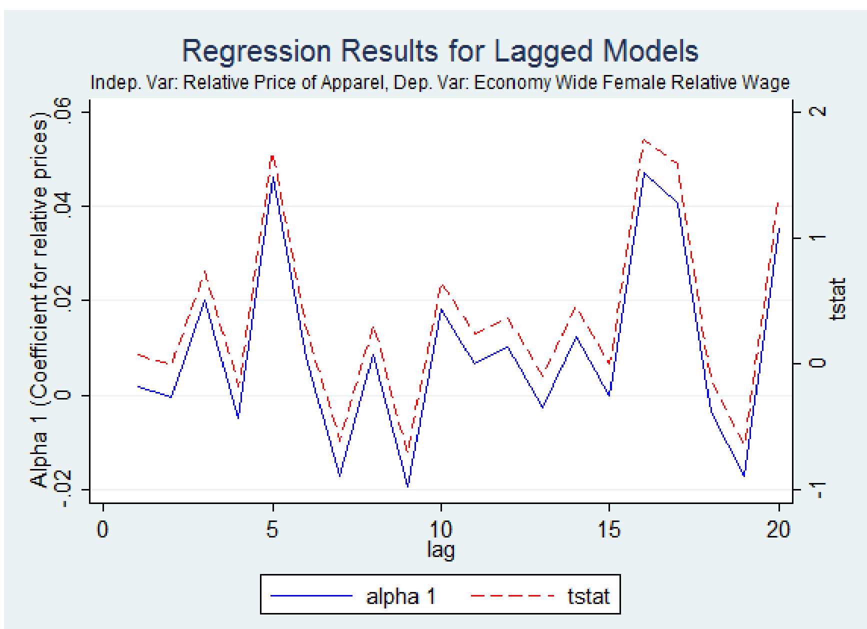


Figure 13.

Figure 14.



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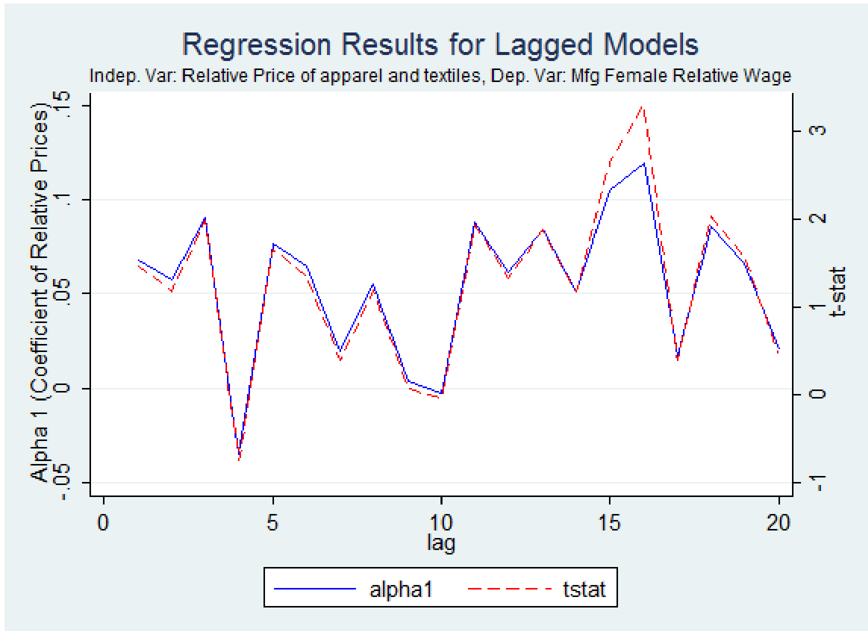

Figure 16.