International Trade, the Gender Wage Gap and Female Labor Force Participation*

Philip Sauré
Swiss National Bank

Hosny Zoabi
The New Economic School

Abstract

Recent work in gender economics has identified trade as a potential determinant of female labor force participation (FLFP). It is usually suggested that FLFP rises whenever trade expands those sectors which use female labor intensively. This paper develops a theoretical model to argue that, quite surprisingly, the opposite effects can occur. Distinguishing between female intensive sectors (FIS) and male intensive sectors (MIS), we show that FLFP may actually fall if trade expands FIS. When FIS are capital intensive, trade integration of a capital-abundant economy expands FIS and contracts MIS. Consequently, male workers migrate from MIS to FIS, diluting the capital labor ratio in the FIS. Under a high complementarity between capital and female labor, the marginal productivity of women drops more than that of men. Thus, the gender wage gap widens and FLFP falls. Employment patterns in the U.S. following NAFTA are broadly consistent with our theory.

Keywords: Female Labor Force Participation, Gender Wage Gap, Home Production, NAFTA.

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Sauré, Swiss National Bank, Boersenstrasse 15, CH-8022 Zurich, Switzerland. E-mail: Philip.Saure@snb.ch. Zoabi, The New Economic School, Nakhimovsky Prospekt, 47, Moscow 117418, Russian Federation. E-mail: hosny.zoabi@gmail.com.

1 Introduction

Does international trade impact female labor force participation, and if so, how? Recently, a number of academic and policy studies have addressed these questions. Most of these studies draw on a Stolper-Samuelson-based intuition, suggesting that whenever trade expands sectors with high female shares in a country, aggregate female labor force participation is bound to increase. For example, the World Bank's World Development Report 2012 observes that "trade openness and economic integration have, in many countries, led to significant growth of export-oriented sectors, with some, such as garments and light manufacturing, employing large numbers of women." Such expansions, the usual argument suggests, result in higher female labor force participation.

The present paper shows that this economic force proves less clear and robust than common intuition would suggest. We argue that, quite surprisingly, aggregate female labor shares may actually *drop* as trade *expands* the sectors that are intensive in female labor. This result, *counterintuitive* as it appears, is generated in a fairly standard general equilibrium trade model with endogenous female labor force participation.

Our modeling strategy extends the framework developed in Galor and Weil (1996). As in this earlier work, female labor and male labor are imperfect substitutes, i.e. they are two distinct factors of production.[1] These two factors are aggregated along with capital in a technology that exhibits a stronger complementarity between capital and female labor than between capital and male labor so that an increase in the capital stock closes the gender wage gap.[2] The preference structure implies that households split their time between childrearing and formal employment.[3] Households' optimization, however, requires that women raise

[1]Acemoglu, Autor, and Lyle (2004) have utilized the large positive shock to demand for female labor induced by World War II to understand the effect of an increase in female labor supply on women's and men's wages. They find that a 10% increase in female labor input decreases women's wages by about 7%−8%, but reduces men's wages by only 3% − 5%. The authors infer that the elasticity of substitution between female and male labor ranges between 2.5 and 3.5.

[2]Goldin (1990) argues that the rapid accumulation of capital during the nineteenth century, which characterized industrialization, was responsible for a dramatic increase in the relative wage of women.

[3]Goldin (1995) provides evidence that shows that few women in the 1940s and 1950s birth cohorts were able to combine childbearing with strong labor-force attachment. Angrist and Evans (1998) and Bailey

children, while men are always fully employed. Finally, female labor supply increases as the gender wage gap closes but is independent of real wage levels since proportional increases in male and female wages have offsetting income and substitution effects.

To allow for international trade, we extend the model of Galor and Weil (1996), introducing two sectors with different factor intensities, which produce two tradable goods. We distinguish between a sector with relatively high demand for female labor labeled the *female intensive sector* and the corresponding *male intensive sector*.[4] For simplicity, we assume that the male intensive sector requires only male labor as input. Therefore, the female intensive sector is also the capital intensive sector while the male intensive sector is the labor intensive one. Capital as well as male and female labor are constrained to remain within national borders. Just as in ordinary Heckscher-Ohlin-type models, the cross-country differences in capital-labor ratios in combination with differences in cross-sector intensities generate patterns of comparative advantage and motives for trade. For a capital-abundant economy, trade brings about an increase in the price of the good produced in the female intensive sector.[5] This price increase, in turn, induces the capital-abundant economy to specialize in the female intensive sector and generates the following two economic forces. First, it raises the factor rewards and, in particular, female wages. However, as male wages are affected proportionately, the gender wage gap and therefore female labor force participation remain constant. Second, the price increase expands production in this sector and induces an inflow of factors to the expanding sector. Given the lower capital intensity in the male-intensive sector, the factor reallocation comprises more labor relative to capital, which dilutes the capital intensity in the female-intensive sector. Given the relatively high complementarity between capital and female labor, the dilution of capital causes the marginal productivity of

(2006) find a negative causal effect running from fertility to female labor force participation.

[4]Using data from United Nations Industrial Development Organization (UNIDO), which is highly disaggregated at the 3- and 4-digit level, we find that the variation across industries in the share of female workers is substantial: it ranges from zero to 100% with a mean of 25% and a standard deviation of 20%.

[5]The specialization pattern presented here is consistent with the evidence presented in Busse and Spielmann (2006) who find that "gender wage inequality is positively associated with comparative advantage in labour-intensive goods", within a sample of 92 developed and developing countries.

women to drop more than that of men. Therefore, the gender wage gap widens, and female labor force participation falls.[6]

The counterintuitive result just discussed crucially relies on the strong complementarity between capital and female labor, which requires a word of justification. Goldin (1990) argues that the rapid accumulation of capital during the nineteenth century, a characteristic of industrialization, was responsible for a dramatic increase in the relative wage of women. Goldin's argument is based on the observation that

> The labor market's rewards for strength, which made up a large fraction of earnings in the nineteenth century, ought to be minimized by the adoption of machinery, and its rewards for brain power ought to be increased (p. 59).

Welch (2000) and Gosling (2003) analyze American and British data, respectively, and read their findings to be consistent with this argument. Black and Spitz-Oener (2010) also attribute the gender wage gap and its dynamics to differences in primary attributes between the genders. They argue that the adoption of the computer into the working space has increased the importance of the non-routine analytic tasks and non-routine interactive tasks, in which women have relative advantages. In a broader sense, our assumption connects to the rich literature on capital-skill complementarity. Krusell, Ohanian, Ríos-Rull, and Violante (2000) find that under capital-skill complementarity, changes in observed inputs alone can account for most of the variations in the skill premium since the 1980s.

With the aim to bring our theory to the data, we turn to the North American Free Trade Agreement between the U.S. (the capital rich economy) and Mexico (the capital scarce economy) during the period 1990 to 2007, which we refer to as the "NAFTA episode".

[6] One may be concerned about the generality of the simple model and whether our results are driven by the specific modeling setup. For example, in the rich economy, our main mechanism depends on male migration from the male intensive sector to the female intensive one, which dilutes the capital labor ratio in the latter. What if the male intensive sector can use capital as a factor of production, which could also be reallocated? Sauré and Zoabi (2011) show that this static result holds with a two-sector economy with constant returns to scale technologies, where all factors are used in both sectors. Moreover, this generalized model reveals that female workers, when laid off in the shrinking sector, may partly turn to home production and partly migrate to the expanding sector. Thus, the impact of trade on female labor in the expanding sector is ambiguous.

We begin our empirical examination with some preliminary observations of sector-level employment in the U.S. and its response to the increased trade with Mexico. Based on trade and employment data for 58 industries, we document that industries for which trade penetration from Mexico increase exhibited a drop in employment.[7] In line with our theory, this effect is strong for male and weak for female employment.

Next, we assess a feature of our model, according to which U.S. exports to Mexico should consist mainly of goods from sectors that are relatively intensive in female labor. Based on data for 58 sectors, we find virtually no correlation between sectorial trade penetration and female intensity. While this observation is not supportive for the corresponding assumptions of our model, we point out that specialization linked to differences in factor endowments is often hidden in industry-level data.[8] Cutting through the data based on 58 broadly defined sectors is thus likely to render inconclusive results. Lacking the necessary data to investigate the micro mechanics of the labor market, we assume instead that the fundamental mechanism advocated by Goldin (1990) and Galor and Weil (1996) does materialize at the micro level. Moreover, based on simple Heckscher-Ohlin considerations, and given the relatively high level of female employment in the U.S., it is more reasonable to think that the U.S. exports female intensive goods to Mexico. Accordingly, we test the predictions of our theory on the aggregate level. Doing so, we stress that the corresponding results are only consistent with our theory on a broad level.

Turning to the country aggregates, our theory offers the following testable predictions: when trading with a poor, capital scarce economy, trade decreases female labor force par-

[7]Trade data are from the Center for International Data, UC Davis; employment data are from the IPUMS-CPS. Merging the corresponding classifications limits the number of final categories to 58. See Section 3 for more information.

[8]The empirical trade literature found that industry-level data hide substantial intra-industry product heterogeneity (Schott 2003). Moreover, Schott (2004) reports that capital-abundant economies use their endowment advantage to produce vertically different varieties. Finally, Bernard, Jensen, and Schott (2006) documents that, as industry exposure to imports from low-wage countries rises, labor in U.S. manufacturing reallocates away from labor-intensive plants and toward capital-intensive plants within industries. Overall, our theory may affect labor reallocation at the intra-industry level: either across vertically superior varieties or across plants with different capital intensities so that industry level data reveals only part of the trade-induced labor reallocation.

ticipation and female relative wage in the rich economy. Central to our estimation strategy are differences between U.S. states in terms of their increase of trade with Mexico during the period 1990-2007.[9] We exploit an exogenous source of cross-state variation in exposure to trade to examine their differential effects on female labor force participation and female relative wage in the U.S.[10]

In light of the potential endogeneity of the change in trade shares, we instrument changes in trade shares by geographic distance and thus identify the impact of exogenous variation in changes in trade shares.[11] Consistent with our theory's predictions, the analysis reveals statistically significant negative impacts of trade expansion on female labor force participation and female relative wage.

To measure the effects of trade on female labor participation, we define our dependent variable as either employment, female hours worked or the share of women in total hours worked. We find that changes in trade shares – instrumented by geographical distance – have negative and significant impacts on these measures of female labor force participation. Importantly, our results remain robust with the inclusion of a large number of control variables. Moreover, since our theory suggests that international specialization affects female labor force participation while male labor force participation remains constant, we test our empirical model on male labor as well and find that changes in trade shares have no significant effect on the different measures of male labor force participation. Finally, to eliminate the possibility that the estimated effects are driven by the low-skill sectors only, we repeat our empirical examination on three different levels of women's education and find that our results hold in all levels of education.

Moving to the effects of trade on female relative wage, we define the dependent variable in

[9] For example, trade with Mexico increased by almost 3.2 percent of total output for Texas, while for New York, the increase was 0.1 percent of total output. We exploit this cross-state variation in the exposure to trade with Mexico to examine how trade has impacted female labor force participation and female relative wage at the state level.

[10] Our approach is similar to Campbell and Lapham (2004), who exploit variations in exposure to international trade to identify the effect of international trade shocks.

[11] Our model actually predicts that higher female labor force participation strengthens the comparative advantage in the capital-intensive sector, which generates higher international specialization and trade.

our regressions as the ratio between women's average wage to men's average wage. Mulligan and Rubinstein (2008) find that the reduction in the gender wage gap during the period 1975-2001 can be attributed to a change in the sign of a selection bias from negative during the 1970s to positive during the 1990s. Accordingly, the presumption in our analysis is that the selection bias during the 1990s was positive. This selection bias mitigates the negative impact of trade on female relative wages as less able women leave the labor market. Indeed, in our baseline regression, we find that the impact of trade on female *average* relative wage is insignificant. We correct for this selection bias by including individuals without reported wage at the lower end of the wage distribution and running the regressions on different percentiles of this new wage distribution. Consistent with our theory, our results reveal a negative impact of trade on female relative wage.

The present study connects to various literatures. On the theory side, our general framework is that of Heckscher-Ohlin-type models (Helpman and Krugman 1985). Given our focus on female labor shares, we need to model a non-trivial elasticity of female labor supply. Doing so, we depart from the conventional approach in which factor endowments are viewed as given and trade patterns are explored, but examine instead how trade affects the supply of factors and female labor force participation. Our paper also connects to the trade literature that analyzes the impact of trade on unemployment (Helpman and Itskhoki 2010).

Until recently, the literature on the impact of international trade on the gender wage gap and female labor force participation was limited to Becker (1971), who argues that trade increases competition among firms, thereby reducing costly discrimination and closing the gender wage gap. Recently, however, the nexus between trade and female labor has received more attention. Aguayo-Tellez, Airola, and Juhn (2010) document that during the 1990s, NAFTA increased employment of Mexican women and thus their bargaining power within their households. This finding is consistent with our theory and, by concentrating on the effects of NAFTA on Mexican women, constitutes the mirror image of our empirical findings. To analyze the increase in female employment in Mexico, Juhn, Ujhelyi, and Villegas-Sanchez

(2014) argue that trade liberalization causes some firms to start exporting and adopting modern technologies that induce higher female employment. Autor, Dorn, and Hanson (2012) use the period 1990 – 2007 in order to examine the impact of rising Chinese import competition on U.S. labor market outcomes. Consistent with our theoretical and empirical finding, the authors show that both male and female employment and the corresponding wages decreased but that these changes were more pronounced for women. Our paper shares features of Galor and Mountford (2008) in the sense that both theories address the effect of international trade on households' optimal choices. Galor and Mountford (2008) endogenized educational choice and fertility choice, arguing that the gains from trade are channeled towards population growth in non-industrial countries while in industrial countries, they are directed towards investment in education and growth in output per-capita. Our theory, which disregards educational choice, highlights the impact on female labor force participation.[12]

The rest of the paper is organized as follows: Section 2 formalizes our argument, section 3 provides empirical evidence and section 4 presents some concluding remarks.

2 The Model

In our modeling strategy we follow Galor and Weil (1996) by adopting a standard OLG model, incorporating the endogenous choice of fertility.[13] At time t the economy is populated by L_t households, each containing one adult man (a husband) and one adult woman (a wife). Individuals live for three periods: childhood, adulthood and old age. In childhood, individuals consume a fixed quantity of their parents' time. In adulthood, individuals raise children, supply labor to the market, and save their wages. In old age, individuals merely consume their savings. The capital stock in each period is equal to the aggregate savings of

[12]It is worth stressing that our mechanism holds not only for child-rearing, but also for any home-produced good whose production requires a time investment on the part of individuals. Nevertheless, our theory is consistent with Do, Levchenko, and Raddatz (2012), who find that countries with comparative advantage in industries employing primarily women exhibit lower fertility.

[13]Kimura and Yasui (2010) extends the model of Galor and Weil (1996) to include non-market work in order to explain the long run dynamics in fertility, male labor participation and female labor participation.

the previous period.

A key assumption is that men and women differ in their labor endowments. While men and women have equal endowments of mental labor units, men have more physical labor units than women. These differences translate into a gender wage gap, which, in turn, governs the trade-off between female labor force participation and fertility.

2.1 Production

2.1.1 Technologies

Two intermediate goods, X_1 and X_2 are assembled into a final good Y by the CES-technology:

$$Y_t = \left(\theta X_{1,t}^{\rho} + (1-\theta) X_{2,t}^{\rho}\right)^{1/\rho} \qquad \rho, \theta \in (0,1). \tag{1}$$

Intermediate goods are produced using three factors: capital K, physical labor L^p, and mental labor L^m. We want to reflect the fact that sectors vary in their factor intensity, in particular, in their intensity of mental and physical labor. These differences in the factor intensity, in turn, generate differences in demand for male and female labor across sectors. Specifically, we impose the following structure on production of intermediate goods:

$$\begin{aligned} X_{1,t} &= aK_t^{\alpha}(L_t^m)^{1-\alpha} + bL_{1,t}^p \\ X_{2,t} &= bL_{2,t}^p. \end{aligned} \tag{2}$$

The variables $L_{i,t}^p$ stand for the physical labor employed in sector i at time t, while L_t^m is the amount of mental labor in the first sector at time t.[14]

[14]Examples of $X2$ production are agriculture, mining or construction if production is conducted in the traditional way. As for $X1$ production, on the one hand, the economic literature has identified an important role for incorporating the computer into the workplace in closing the gender wage gap. On the other hand, one may wonder of a sector that uses computers and still needs physical labor as an input of production. Our example of such a sector is a package delivery company such as UPS in the U.S. However, could this example be generalized to be presented at the macro level? Interestingly, Bacolod and Blum (2010) found that physical strength is required in 8 percent of the occupations of college graduates, 27 percent of high school graduates jobs and in 46 percent of jobs occupied by workers without a high school degree. This implies that, on average, individuals supply their physical strength in combination with mental skills even

2.1.2 Labor Endowments and Labor Allocation

Men and women are equally efficient in raising children. However, men and women differ in their endowments that are relevant for the labor market: while each woman is endowed with one unit of mental labor L^m, each man is endowed with one unit of mental labor L^m plus one unit of physical labor L^p. Thus, as long as physical labor has a positive price, men receive a higher wage than women and therefore the opportunity cost of raising children is higher for a man than for a woman. Consequently, men only raise children when women are doing so full-time. Finally, we assume that a male worker cannot physically divide his two types labor and must allocate both units to only one sector. This means, in particular, that men employed in the X_2-sector waste their mental endowment.

2.2 Preferences

Individuals born at $(t-1)$ form households in period t and derive utility from the number of their children n_t and their joint old-age consumption c_{t+1} of a final good Y according to[15]

$$u_t = \gamma \ln(n_t) + (1-\gamma)\ln(c_{t+1}). \tag{3}$$

We assume that parents' time is the only input required to raise children and thus the opportunity cost of raising children is proportional to the market wage. Let w_t^F and w_t^M be the hourly wage of female and male workers, respectively. Normalizing the hours per period to unity, the full monetary income of a household is $w_t^M + w_t^F$ when wife and husband are both working full time.

Further, let z be the fraction of the time endowment of one parent that must be spent to raise one child. If the wife spends time raising children, then the marginal opportunity cost of a child is zw_t^F. If the husband spends time raising children, then the marginal opportunity

in highly skilled occupations.

[15]Note that since the basic unit is a household which consists a husband and wife, n_t is, in fact, the number of pairs of children that a couple has.

cost of a child is zw_t^M. The household's budget constraint is therefore

$$\begin{aligned} w_t^F zn_t + s_t \leq w_t^M + w_t^F \qquad & if \qquad zn_t \leq 1 \\ w_t^F + w_t^M(zn_t - 1) + s_t \leq w_t^M + w_t^F \qquad & if \qquad zn_t > 1 \end{aligned} \tag{4}$$

where s_t is the household's savings. In the third period, the household consumes its savings

$$c_{t+1} = s_t(1 + r_{t+1}) \tag{5}$$

where r_{t+1} is the net real interest rate on savings.

2.3 Optimality

It will prove useful to conduct the analysis in terms of per-household variables. We therefore define:

$$k_t = K_t/L_t \qquad m_t = L_t^m/L_t \qquad l_{i,t} = L_{i,t}^p/L_t$$

as capital, productive mental labor and sectorial physical labor *per-household*, respectively. Finally, we define

$$\kappa_t = k_t/m_t \tag{6}$$

as the ratio of capital to mental labor employed in the first sector. This ratio will play a central role in the following analysis.

2.3.1 Firms

Perfect competition in the final good sector implies, by (1) and (2), that the relative price is

$$\pi_t = \frac{p_{2,t}}{p_{1,t}} = \frac{1-\theta}{\theta}\left(\frac{X_{1,t}}{X_{2,t}}\right)^{1-\rho} = \frac{1-\theta}{\theta}\left(\frac{a\kappa_t^\alpha m_t + bl_{1,t}}{bl_{2,t}}\right)^{1-\rho}, \tag{7}$$

where we write $p_{i,t}$ as X_i's price in period t. Given $p_{i,t}$, cost minimizing final good producers leads us to the usual ideal price index P_t, which we normalize to one

$$P_t = \left(\left(\frac{\theta}{p_{1,t}^{\rho}} \right)^{1/(1-\rho)} + \left(\frac{1-\theta}{p_{2,t}^{\rho}} \right)^{1/(1-\rho)} \right)^{-(1-\rho)/\rho} = 1. \tag{8}$$

From equation (2) the return to capital in the first sector is

$$r_t = p_{1,t}\alpha a \kappa_t^{\alpha-1} \tag{9}$$

Wages are derived from (2) and reflect the marginal productivity of labor. Male shadow wages of the two sectors are determined by productivities and prices of the two sectors:

$$w_{1,t}^M = p_{1,t}b[(1-\alpha)a/b\kappa_t^{\alpha} + 1] \tag{10}$$

$$w_{2,t}^M = p_{2,t}b, \tag{11}$$

These expressions reflect mental and physical labor productivity in the first sector, and physical labor productivity in the second sector. The prevailing market wage for male workers is then

$$w_t^M = \max\{w_{1,t}^M, w_{2,t}^M\} \tag{12}$$

Similarly, female shadow wage is

$$w_t^F = p_{1,t}(1-\alpha)a\kappa_t^{\alpha}, \tag{13}$$

which reflects mental labor productivity in the first sector.

2.3.2 Households

Household's maximizing problem yields

$$zn_t = \begin{cases} \gamma(1 + w_t^M / w_t^F) & if \quad \gamma(1 + w_t^M / w_t^F) \leq 1 \\ 2\gamma & if \quad 2\gamma \geq 1 \\ 1 & otherwise. \end{cases} \tag{14}$$

Equation (14) implies that in the case in which $\gamma \geq 1/2$ women raise children full time regardless of their wages. We rule out this scenario by imposing $\gamma < 1/2$. Under this restriction, women raise children full-time only under relatively high gender wage gaps. But as the gender gap decreases women join the labor force and fertility decreases. When w_t^F approaches w_t^M, women spend a fraction 2γ of their time raising children. Finally, under our assumption $\gamma < 1/2$ the budget constraint (4) collapses to

$$s_t = (1 - zn_t) w_t^F + w_t^M \tag{15}$$

and (14) becomes with $\omega_t = w_t^M / w_t^F$

$$zn_t = \min \left\{ \gamma \left(1 + \omega_t\right), 1 \right\}. \tag{16}$$

2.4 Closed Economy

2.4.1 Static Equilibrium

The equilibrium of the integrated economy is determined separately for two regimes. The first is a regime in which women do not participate in the formal labor market, and the second is a regime in which women participate. To simplify the analysis, we assume that, in equilibrium, the second sector is too small to accommodate all male labor. Specifically, we assume[16]

$$2-\alpha \geq 1/\theta \tag{17}$$

to be satisfied throughout the following analysis. Under this assumption, $L_{1,t}^{p}>0$ holds and the ratio of male to female wage can be computed by the marginal productivities in the first sector

$$\omega_t = 1+\frac{b}{(1-\alpha)a\kappa_t^{\alpha}}. \tag{18}$$

This ratio determines female labor force participation $1-zn_t$ through (16)

$$zn_t = \min\left\{\gamma\left(2+\frac{b}{(1-\alpha)a\kappa_t^{\alpha}}\right),1\right\}. \tag{19}$$

To determine equilibrium κ_t, combine male wage (12), prices (7), and the resource constraint for male labor $1=l_{1,t}+l_{2,t}$ to get

$$(1-\alpha)\frac{a}{b}\kappa_t^{\alpha}+1=\frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\kappa_t^{\alpha}m_t+l_{1,t}}{1-l_{1,t}}\right)^{1-\rho}. \tag{20}$$

Further note that

$$l_{1,t}=m_t-(1-zn_t) \tag{21}$$

so that equation (20) becomes

$$(1-\alpha)\frac{a}{b}\kappa_t^{\alpha}+1=\frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\kappa_t^{\alpha}m_t+m_t-(1-zn_t)}{1-m_t+(1-zn_t)}\right)^{1-\rho}. \tag{22}$$

Equations (6), (19), and (22) determine m_t and zn_t and thus the equilibrium. There are two qualitatively different types of equilibria to distinguish.

The First Regime $zn_t=1$. In the case in which $zn_t=1$, equation (22) can be written in

[16] A sufficient condition for $l_{1,t}>0$ is that the relative price (7) falls short of the ratio of marginal rates of transformation at $l_{1,t}=0$ and $zn_t=0$ i.e. $(1-\alpha)\kappa_t^{\alpha}a/b+1>(1-\theta)/\theta\,(\kappa_t^{\alpha}a/b)^{1-\rho}$. If $\kappa_t^{\alpha}a/b\geq 1$ then this sufficient condition is implied by $(1-\alpha)\geq(1-\theta)/\theta$, or (17). If $\kappa_t^{\alpha}a/b<1$ instead, the sufficient condition is implied by $1>(1-\theta)/\theta$ and hence, again, by (17).

terms of κ_t (substitute $m_t = k_t/\kappa_t$):

$$(1-\alpha)\frac{a}{b}\kappa_t^{\alpha} + 1 = \frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\frac{k_t}{\kappa_t^{1-\alpha}} + \frac{k_t}{\kappa_t}}{1-\frac{k_t}{\kappa_t}}\right)^{1-\rho}. \tag{23}$$

The Second Regime $zn_t < 1$. In case in which $zn_t < 1$ we use $m_t = k_t/\kappa_t$ and zn_t from (19) to write (22) as

$$(1-\alpha)\frac{a}{b}\kappa_t^{\alpha} + 1 = \frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\frac{k_t}{\kappa_t^{1-\alpha}} + \frac{k_t}{\kappa_t} - 1 + \gamma\left(2 + \frac{b}{a}\frac{\kappa_t^{-\alpha}}{1-\alpha}\right)}{1-\frac{k_t}{\kappa_t} + 1 - \gamma\left(2 + \frac{b}{a}\frac{\kappa_t^{-\alpha}}{1-\alpha}\right)}\right)^{1-\rho}. \tag{24}$$

Equations (23) and (24) determine the equilibrium κ_t in the first and second regime, respectively. Notice that expressions on the left of both equations are increasing in κ_t, while both terms on the right are decreasing in κ_t. This implies that κ_t is unique in both regimes. Moreover, the expressions on the right of (23) and (24) are increasing in k_t so that $\kappa_t(k_t)$ is an increasing function.

Quite intuitively, a capital-rich economy has a higher capital-mental labor share than a capital-scarce economy. When going back to equation (19), this observation shows also that the higher the capital stock k_t of an economy, the lower fertility zn_t is. As $\kappa_t(k_t)|_{k_t=0} = 0$, (19) further implies that there is a $k_o > 0$ so that the economy is in the first regime when its capital stock falls short of k_o, while the economy is in the second regime if not. By combining the according condition $\gamma\left(2 + b/\left[(1-\alpha)a\kappa_o^{\alpha}\right]\right) = 1$ with equation (23) and $\kappa_o = k_o/m_o$, this threshold is shown to be

$$k_o = \theta\,(1-\gamma)\left(1 - 2\gamma + \gamma\frac{1-\alpha\theta}{1-\alpha}\right)^{-1}\left[\frac{(1-\alpha)(1-2\gamma)}{\gamma}\frac{a}{b}\right]^{-1/\alpha}. \tag{25}$$

At capital stocks below the threshold k_o all women raise children full-time. When capital is gradually accumulated and this threshold is passed, women integrate into the labor market and, as the variable κ_t keeps increasing, the gender wage gap closes and female labor supply rises. At the same time, and as a mirror image, fertility declines.

2.5 International Trade

We now turn to the effects of international trade in goods.[17] As trade induces specialization at the country level, countries expand some sectors while contracting others. As sectors differ in intensity of male and female labor, international specialization affects relative wages within each country. In the following paragraphs, we explore these effects of trade on the gender wage gap and the consequences for fertility and female labor force participation.

We assume that the world consists of two countries, Home (no *) and Foreign (*). In addition, the superscript ^{A} indicates autarky variables, while its absence indicates variables of the free trade equilibrium. Moreover, we denote the relative population size of Foreign to Home by $\lambda_t = L_t^*/L_t$.

Writing $\bar{k}_t$ for the average per household capital stock of the world economy, we define the set of all possible factor distributions in a world as:

$$FD_t = \left\{ (\lambda_t, k_t, k_t^*) \mid \lambda_t \in [0, \infty];\ k_t, k_t^* \geq 0 \text{ and } \left(k_t + \lambda_t k_t^*\right)/(1+\lambda_t) = \bar{k}_t \right\}, \tag{26}$$

This definition comprises all possible partitions of the capital stock. Notice that the definition depends on the world capital ratio $\bar{k}_t$ but is independent of the world population size $L_t+L_t^*$.[18]

[17] We assume that capital is immobile, i.e. it is restricted to remain within national borders. This is partly motivated by the strong home-bias of investment and, more importantly for our purpose, by the fact that differences in the factor content of trade are consistent with the Heckscher-Ohlin predictions (Debaere 2003).

[18] The definition thus slightly deviates from the standard definition in the sense that it is formulated "modulo population size."

2.5.1 Factor Price Equalization

A good starting point for the analysis of the free trade equilibrium is the Factor Price Equalization Set[19]

$$FPES_t = \left\{ (\lambda_t, k_t, k_t^*) \in FD_t \mid w^M = w^{*,M}, \ w^F = w^{*,F}, \ r = r^* \right\}. \qquad (27)$$

Among all possible distributions of factors across countries, the $FPES_t$ comprises those that lead to free trade equilibria characterized by identical factor prices across countries. In terms of prices and output, these equilibria then replicate the equilibrium of an integrated world economy where factors are not restricted by national borders.[20] Thus, the $FPES_t$ describes the conditions on factor distributions under which borders do not affect the world efficiency frontier. Loosely conceptualized, a factor allocation is an element of the $FPES_t$ if relative factors are distributed "not too unevenly".

The following proposition conveniently characterizes the $FPES_t$ of the present model.

Proposition 1

Factor prices equalize if and only if $\kappa_t^* = \kappa_t$.

Proof. See Appendix. ■

The proposition shows that $\kappa_t = \kappa_t^* = \bar{\kappa}_t$ implies $\omega_t = \omega_t^*$, a regime in which fertility, determined by (16), equalizes in both countries: $zn_t = zn_t^* = z\bar{n}_t$.[21] Combining these equations leads to:

$$\bar{\kappa}_t = \frac{k_t}{l_{1,t} + 1 - z\bar{n}_t} = \frac{k_t^*}{l_{1,t}^* + 1 - z\bar{n}_t}. \qquad (28)$$

By the definition of the $FPES_t$, $\bar{\kappa}_t$ and $\bar{n}_t$ are also the capital-mental labor ratio and fertility of the integrated world economy.

[19]Remember that the absence of superscript ^{A} indicates equilibrium variables under free trade – *e.g.* at w^M, $w^{*,M}$ etc.

[20]If the equilibrium of the integrated economy is replicated, factors in all countries must equalize. Conversely, if factor and good prices equalize in both countries, the world equilibrium is an equilibrium of the integrated economy.

[21]Upper bars indicate variables of the integrated economy.

For the rest of the analysis, and without loss of generality Home will represent the capital scarce and Foreign the capital abundant country, i.e., we assume that $k_t < k_t^*$ for the initial period. Making use of this inequality in combination with (28), we observe that $l_{1,t} < l_{1,t}^*$ and thus $l_{2,t} > l_{2,t}^*$. Consequently, the relevant resource constraints $l_{1,t}, l_{2,t}^* \leq 1$ lead to a restriction on capital stock conditions for factor price equalization to hold:

$$(1 - z\bar{n}_t)\bar{\kappa}_t \leq k_t, k_t^* \leq (2 - z\bar{n}_t)\bar{\kappa}_t \tag{29}$$

As capital stocks of both countries add up to the aggregate world capital stock ($\bar{k}_t = (k_t + \lambda_t k_t^*) / (1 + \lambda_t)$), the $FPES_t$ is described by (29) and

$$\lambda_t = \frac{\bar{k}_t - k_t}{k_t^* - \bar{k}_t}. \tag{30}$$

Using the concise graphical representation from Helpman and Krugman (1985), Figure 1 illustrates the $FPES_t$. Each point A on the plane represents a partition of world labor and world capital: the distance between the vertical axis and A represents Home's male labor L_t, while the distance between the horizontal axis and A represents Home's capital K_t; Foreign's variables are $L_t^* = \bar{L}_t - L_t$ and $K_t^* = \bar{K}_t - K_t$, respectively. Since female labor shares are determined by the gender wage gap and hence by factor prices only, factor price equalization implies that female labor shares equalize in both countries. Thus, in the case where global female labor shares are positive, Home must hold a minimum level of capital to keep X_1-production operating and generate jobs in this sector. This case is illustrated in the top panel of Figure 1. If, instead, global female labor shares are zero, Home may in fact entirely lack capital. By fully specializing on X_2-production, Home's factor prices may still equalize with Foreign's. In this case, which is illustrated by the bottom panel of Figure 1, the equilibrium of the integrated economy is replicated.

We can now readily determine the specialization pattern of both economies under the assumption that factor prices equalize. Recalling assumption $k_t < k_t^*$, we observe:

$$m_t = k_t/\bar{\kappa}_t < k_t^*/\bar{\kappa}_t = m_t^*,$$

while

$$l_{2,t} = 1 - [m_t - (1 - z\bar{n}_t)] > 1 - [m_t^* - (1 - z\bar{n}_t)] = l_{2,t}^*.$$

Confirming Heckscher-Ohlin-based intuition, the capital scarce Home country specializes in production of the labor intensive good, X_2, while capital abundant Foreign specializes in X_1-production.

We can further compare the trade equilibrium with the respective autarky equilibria. To do so, we use $\kappa_t^A < \bar{\kappa}_t < \kappa_t^{*,A}$ and (19) to conclude:

$$zn_t^A \geq z\bar{n}_t \geq zn_t^{*,A}.$$

These inequalities are strict if $1 > zn_t^A$ holds. Consequently, relative to autarky, trade increases female labor force participation in the capital scarce country and decreases it in the capital abundant country.

These observations combined imply that the country which, by international specialization, *contracts* the sector that is particularly suitable for female labor, experiences an *increase* in female labor force participation. Conversely, the country which *expands* the sector suitable for female labor, experiences a *decrease* in female labor force participation.

The reason for this seemingly paradoxical finding is the following. For each economy, the key determinant of female labor force participation is the gender wage gap $\omega_t^{(*)}$. In autarky and under factor price equalization, this gender wage gap is determined by the relative productivities in the X_1-sector via (18) and ultimately by the capital-mental labor ratio $\kappa_t^{(*)}$. When international specialization induces Home to contract its X_1-sector and expand its X_2-sector, male workers move from the first to the second sector, taking their mental labor with them. Thus, they increase the ratio κ_t and thereby foster female labor force participation

$(1-zn_t)$. Conversely, when Foreign workers react to trade-induced international price shifts and move from the second to the first sector, they dilute the capital-mental labor share κ_t^*, which increases the gender wage gap and decreases female labor force participation.[22]

In sum, under factor price equalization, we get sharp results on the impact of trade on female labor force participation in the capital scarce and abundant countries, respectively. The key mechanism for the result described above, however, depends on the fact that the gender wage gap is a function of the capital-mental labor ratio $\kappa_t^{(*)}$. The extent to which these results generalize beyond factor price equalization is the subject of the next subsection.

2.5.2 Beyond Factor Price Equalization

Let us begin the general case of international trade by focusing on one country, for example, Home, with exogenous relative world prices π_t – i.e., for the moment, we assume that Home is a small open economy. We determine how the equilibrium gender wage gap ω_t changes with world price $\pi_t = p_{2,t}/p_{1,t}$. This is done in the following Lemma.

Lemma 1

(i) For given capital endowment k_t there are $\underline{\pi}, \overline{\pi}$ with $0 < \underline{\pi} < \pi_t^A < \overline{\pi}$ so that

$$\frac{d}{d\pi_t}\omega_t(\pi_t) = \begin{cases} 0 & \text{if } \pi_t \leq \underline{\pi} \\ < 0 & \text{if } \pi_t \in (\underline{\pi}, \overline{\pi}) \\ > 0 & \text{if } \pi_t \geq \overline{\pi} \end{cases}$$

(ii) Output of the X_1- (X_2-) sector is weakly decreasing (increasing) in π_t.

Proof. (i) At autarky price π_t^A, we have $l_{1,t}, l_{2,t} > 0$, as shown in the closed economy. Combining (10), (11), and (13) we have $\pi_t = (1-\alpha)\, a/b\kappa_t^{\alpha} + 1$ and $\omega_t = \pi_t[(1-\alpha)\, a/b\kappa_t^{\alpha}]^{-1}$

[22] The effect of relative productivities on the gender wage gap, which is the core of our mechanism operates under substantial generalizations. If $F(K, M, L)$ represents a standard constant return to scale production function in the first sector, it is sufficient to assume that capital K complements mental labor M relatively more than physical labor L (*i.e.* , $F_{KM}/F_M > F_{KL}/F_L \geq 0$, in line with Goldin (1990) and Galor and Weil (1996)) in order to generate the effect discussed. In particular, under these conditions, higher male employment in the first sector increases the gender wage gap (Sauré and Zoabi 2011).

and hence

$$\omega_t = \frac{\pi_t}{\pi_t - 1} \tag{31}$$

as long as $l_{1,t}, l_{2,t} > 0$, implying that ω_t is decreasing in π_t. By (16) this means that zn_t is decreasing in π_t, in this range too. Further, $\pi_t = (1-\alpha)\, a/b\kappa_t^{\alpha} + 1$ implies that $\kappa_t = k_t/m_t$ is increasing in π_t and hence, as $m_t = l_{1,t} + 1 - zn_t$, must be decreasing in π_t. Therefore, $l_{1,t}(\pi_t)$ is decreasing in π_t. The constraint $l_{1,t} \in [0,1]$ then implies that there are two prices $\underline{\pi}$ and $\overline{\pi}$ so that $l_{1,t}(\underline{\pi}) = 1$ and $l_{1,t}(\overline{\pi}) = 0$. Consider now prices π_t with $\pi_t \leq \underline{\pi}$ and check that (12) gives

$$\omega_t = 1 + [(1-\alpha)\, a/b\kappa_t^{\alpha}]^{-1} \tag{32}$$

Thus, ω_t is constant in π_t (check with (10) and (11) that $l_{1,t} = 1$ throughout this range). For prices π_t satisfying $\pi_t \geq \overline{\pi}$ (12) implies

$$\omega_t = \pi_t[(1-\alpha)\, a/b\kappa_t^{\alpha}]^{-1} \tag{33}$$

Thus, starting at $\pi_t = \overline{\pi}$, increases in π_t cannot increase $m_t = 1 - zn_t$ ((16) would require a decrease in ω_t contradicting equation (33)) and must widen the gender wage gap ω_t. Check with (10) and (11) that $l_{1,t} = 0$ throughout this range.

(ii) Output of X_2 is proportional to $1 - l_{1,t}$ and $l_{1,t}$ has been shown to be decreasing in (i). – Consider output of X_1. In the range $\pi_t < \underline{\pi}$, $l_{1,t} = 1$ and ω_t constant. Hence, $m_t = l_{1,t} + 1 - zn_t$ is constant and so is output of X_1. In the range $\pi_t \in (\underline{\pi}, \overline{\pi})$ the gender wage gap ω_t is decreasing and hence κ_t increases, as (18) holds. Thus, X_1 from (2) decreases. Finally, for $\pi_t > \overline{\pi}$ the employment $m_t = 1 - zn_t$ in X_1-sector decreases (ω_t increases while $l_{1,t} = 0$ holds). Thus, X_1 output falls. ■

Figure 2 summarizes part (i) of the Lemma. For small π_t, the gender wage gap $\omega_t\,(\pi_t)$ is constant: all factors are employed in the first sector and small price changes do not change the labor allocation, so that relative factor rewards are constant. Conversely, for $\pi_t > \bar{\pi}$, all male workers are employed in the second sector, while capital and female labor are employed in the first sector. Again, small price changes do not change the labor allocation, but translate one-to-one into changes in the wage gap. Finally, for the intermediate range $\pi_t \in (\underline{\pi}, \bar{\pi})$, the gender wage gap $\omega_t(\pi_t)$ is decreasing through the effects of labor allocation explained already in the case of factor price equalization. By the generic relation (16), these swings in ω_t are paralleled by swings in zn_t.

Part (ii) of the Lemma simply states the basic scheme of international trade: as import prices drop, an economy increases its import volume and shifts production towards its export sector.

Now consider the previously autarkic Home economy that suddenly opens up to trade and now faces relative world prices $\pi_t < \pi_t^A$. Relative to autarky, the gender wage gap ω_t increases (notice that $l_{1,t} > 0$ and compute $w_{M,t}/w_{F,t}$ with (10)-(13)). Hence, fertility n_t rises while female labor participation $(1 - zn_t)$ drops. At the same time trade expands the X_1-sector and contracts the X_2-sector. If, instead, $\pi_t > \pi_t^A$, then two outcomes are possible. First, if π_t is not too large, then the effect of trade is a reduction in the gender wage gap ω_t and thus a decrease in fertility n_t plus an increase in female labor force participation $(1 - zn_t)$. Second, if π_t is sufficiently large, then trade induces an increase in ω_t and n_t and a decrease in $(1 - zn_t)$. In Figure 2, the threshold that separates the two cases is labeled π_u.[23] In either case, trade contracts the X_1-sector and expands the X_2-sector.

Returning now to the trade equilibrium between capital scarce Home and capital abundant Foreign, we observe that the autarky prices of both countries are (18), so that, by the relative capital scarcity, $\pi_t^A < \pi_t^{*,A}$ holds (compare (7)). In the regime with international trade, the world price π_t lies between the respective autarky prices:

$$\pi_t^A \leq \pi_t \leq \pi_t^{*,A}. \tag{34}$$

[23]Notice that this threshold π_u depends on the capital stock of the economy and could be written as $\pi_u(k_t)$.

Thus, trade (weakly) increases relative prices π_t in Home while it (weakly) decreases them in Foreign. With this observation, we can apply the insights of Lemma 1. For the capital abundant Foreign, trade unambiguously causes a (weak) increase in the gender wage gap ω_t and thus a drop in female labor force participation. We can therefore generalize the first part of our result derived under factor price equalization. The country which, by international specialization, expands the sector suitable for female employment experiences a decrease in female labor force participation.

For capital scarce Home, however, trade induces a decrease in the wage gap ω_t and an increase in female labor force participation if and only if π_t is not too high (i.e., $\pi_t \leq \pi_u$ holds).[24] In this restricted case, we recover the second part of the result derived under factor price equalization. The country which contracts the sector suitable for female labor experiences an increase in female labor force participation. This second observation is a non-trivial generalization of the parallel result under factor price equalization. To verify this statement, use that under free trade $l^*_{1,t} > 0$ and $l_{2,t} > 0$ hold so that, by (10) and (11)

$$(1-\alpha)\frac{a}{b}(\kappa^*_t)^{\alpha} + 1 \geq \pi_t \geq (1-\alpha)\frac{a}{b}\kappa^{\alpha}_t + 1 \tag{35}$$

holds. Proposition 1, however, states that factor price equalization requires $\kappa_t = \kappa^*_t$, implying $\pi_t = (1-\alpha)\frac{a}{b}\kappa^{\alpha}_t + 1$. By construction of $\bar{\pi}$, however, all world equilibria with $\pi_t \in (\overline{\pi}, \pi_u)$ are characterized by equality $\pi_t > (1-\alpha)\frac{a}{b}\kappa^{\alpha}_t + 1$, implying that factor prices do not equalize. Since finally, by construction of π_u we have $\omega_t > \omega^A_t$ for all equilibria with $\pi_t \in (\overline{\pi}, \pi_u)$ we conclude that trade induces an increase of female labor force participation in Home for a set of factor endowments that is strictly larger than the $FPES_t$.

Summarizing, we use the definitions (26) and (27) to state the following proposition.

Proposition 2

[24] Notice that, by assumption (17) $\pi^{*,A}_t < \pi_u$ holds for Foreign. However, the threshold $\pi_u(k^*_t)$ depends on Foreign's capital and one cannot conclude that $\pi_t \leq \pi^{*,A}_t < \pi_u(k_t)$ holds.

(i) In Foreign, trade expands the sector that uses female labor intensively, but unambiguously reduces female labor force participation.

(ii) There is a set $S_t \subset FD_t$ with $FPES_t \subsetneq S_t$ and the following property: for each element of S_t trade contracts the sector that uses female labor intensively in Home, but increases Home's female labor force participation.

It is important to stress that this general result does not rely on the close link between female labor force participation and fertility. Instead any time-intensive home production will render the very same result.

Notice that, by virtue of the previous Lemma, the first statement of the proposition also holds at the margin. Any marginal trade liberalization in the capital rich country that lowers the relative import over export price widens the gender wage gap and hence decreases female labor force participation.

Proof. See Appendix. ■

3 Empirical Evidence

The theoretical model developed in the preceding section predicts that trade integration between a capital-poor and a capital-rich economy widens the gender wage gap in the latter. Under the equilibrium factor reallocation, this means that trade integration eventually decreases aggregate female labor force participation in the capital-rich economy.

With the aim to bring this prediction to the data, we turn to the episode of U.S.-Mexican trade integration during the period 1990-2007, a period, which we will refer to in the following as the "NAFTA episode".[25] Studying the NAFTA episode has a number of virtues. First, the U.S. and Mexico are paradigmatic for a pair consisting of a capital-rich and a capital-

[25] This label is misleading to the extent that not all of the increase in US-Mexican trade is attributed to tariff reductions of NAFTA. In fact, Krueger (1999) argues that Mexico's unilateral tariff reduction in the late 1980s and its abandoning of the exchange rate peg explains most of the increase in trade volumes. For the purpose of our test, however, this observation is of minor importance. We are only concerned about identifying an episode of substantial increase in trade volumes.

poor economy with intense trade ties.[26] Second, not only can the period be classified as a *de jure* trade liberalization, but U.S.-Mexican trade has also grown substantially: measured as a share of U.S. GDP, it increased more than three-fold between 1990 and 2007, and Mexico's share in U.S. total trade rose by a factor of more than two (Figure 5). By the sheer size of the increase of trade volumes, in turn, we can hope to identify a sizable impact of trade on labor markets. Third, the choice of the NAFTA episode allows us to take advantage of the high quality of U.S. trade and labor market data. Finally, due to the specific geographical constellation between the U.S. and Mexico, trade flows are particularly uneven across the different U.S. states. This variation allows us to identify the impact of trade expansion on the U.S. labor market.

3.1 Initial Observations

Having selected the NAFTA episode as the appropriate field to test our theory, we first investigate whether the data display some of the basic patterns our theory rests on. The most basic feature of our theory – which it shares with the vast majority of trade models – is that labor migrates from shrinking sectors with increased import penetration to expanding sectors with higher export performance. As Mexico accounts for a large, but certainly not the dominant fraction of U.S. trade, it is appropriate to verify that, indeed, the U.S. labor market responded in a significant way to the increased trade with Mexico. Accordingly, we examine whether those sectors, which experienced an increase (decrease) in net import penetration from Mexico did exhibit a drop (rise) in employment. The top panel of Figure 3 plots the percentage changes of U.S. employment (measured in total hours worked) against the increases in bilateral import penetration from Mexico (defined as changes of real value of net imports normalized by the wage bill in the initial period). Each observation corresponds

[26] Capital stocks per worker can be calculated from real investment data as in PWT6.2. At depreciation rates of between .01 and .1, the relative capital stock of the U.S. in 2003 exceeded that of Mexico by a factor of four. Consistent with our theory, the female labor share in the U.S. ranged from 43.1 to 46.3 between 1985 and 2006, while the according range for Mexico is 29.4 to 35.3 (United Nations Statistics Division).

to one of 58 different sectors; changes are between the two periods 1990/91 and 2006/07.[27] The scatter plot shows that those sectors, for which the penetration of imports from Mexico increased, exhibited a decrease in total employment. Column I of Table 1 reports the corresponding OLS regression, showing a non significant negative relation.

Moving towards the more specific mechanics of our theory, we next distinguish between the reallocation of male and female workers. This distinction is crucial because while aggregate female labor is predicted to fall in the capital rich country, our theory offers no predictions at the industry level. Specifically, given our strong assumption of technologies, women are never employed in the male intensive sector and hence female labor does not relocate from that sector. In addition, a generalization of this model shows that female workers, when laid off in the shrinking sector, may partly turn to home production and partly migrate to the expanding sector.[28] In that case, female labor in the expanding sector may actually drop, remain unchanged or even rise. On the contrary, male labor is always predicted to rise in the expanding and fall in the contracting sectors. These distinct predictions for the response of male and female labor to trade prompt us to differentiate the patterns of labor reallocation by gender. We thus plot only the percentage change of male hours worked against the previous measure of import penetration (bottom panel of Figure 3).

The figure shows a more pronounced labor reallocation during the NAFTA episode for male workers. Columns II and III of Table 1 report the OLS regression between changes in male and female employment on the one side and the changes in import penetration on the other. In line with our theory, changes in male labor exhibit a negative relation that is significant at the 5 percent level (Column II); the corresponding coefficient suggests that

[27]Bilateral trade data are from United States Import And Export Data (available at http://cid.econ.ucdavis.edu/). Products are classified according to the 6-digit Naics 1997 system and can thus be mapped into the IPUMS-CPS classification system using the Industry Code Crosswalk from the US Census Bureau. Merging the 316 categories from Naics and 243 from IPUMS-CPS reduced the number of goods categories to 60; for 58 of these exist employment data. Nominal values are deflated by the U.S. GDP deflator from the Bureau of Economic Analysis at www.bea.gov. Since the yearly trade data stops in 2006, we proxy the trade in 2006/07 data by the according data for 2005/06. Employment and wage data are from IPUMS-CPS, aggregated by sector. The total wage bill in the initial period is defined as the sum of individual wage income reported in the IPUMS-CPS, adjusted for the sample coverage.

[28]See Sauré and Zoabi (2011).

a ten percent increase in import penetration is associated with a 4.8 percent reduction of male labor. Also as expected, when contemplating the ambiguous predictions of female labor on the sector level, the coefficient relating female labor reallocation and changes in import penetration is small and insignificant.

These general impressions are corroborated by the adoption of a different measure of import penetration from Mexico. Specifically, we regress the change in sectorial import penetration from Mexico on the corresponding change in sectorial import penetration from 20 advanced economies.[29] The residual of this regression can be regarded as the increase in bilateral import penetration with Mexico, which was not generated by a general expansion of sectorial demand or shifts in the U.S. comparative advantage against the rest of the world. We therefore take this residual as a cleansed measure of the increase in bilateral import penetration and repeat the regressions specified in the first three columns of Table 1. The corresponding Columns IV, V and VI show that the results are very similar.[30]

A further important characteristic feature of our theory is that the capital rich country specializes in sectors that are relatively intensive in female labor. When trying to identify these patterns in the data, our expectations are trimmed by the well-known fact that trade flows typically relate very loosely to factor intensities on the broader industry level (Trefler 1995). We therefore reluctantly plot the change in sectorial import penetration from Mexico against the initial female labor shares. A generous reading of Figure 4 detects a slight negative correlation between both variables (which would support our theory); the general picture, however, is certainly inconclusive. Based on the pattern exhibited in Figure 4, one would not expect an effect of increased bilateral trade with Mexico on U.S. female labor shares. It is important, however, to recall that recent contributions to the literature have documented that the largest part of factor reallocation takes place *within* industries or even

[29] These economies are Australia, Austria, Belgium-Luxemburg, Canada, Denmark, Finland, France, Germany, Hon Kong, Iceland, Ireland, Japan, Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, Taiwan and the UK.

[30] The results are qualitatively unchanged when taking residual Mexican import penetration from a regression of U.S.-Mexican trade on U.S. trade with the rest of the world (not reported).

within plants (Schott 2003, Schott 2004, Bernard, Jensen, and Schott 2006).[31] Thus, the goal of testing our theory should not be frustrated by the expected weak correlation displayed in Figure 4. Instead, there are two general strategies we can turn to when testing the predicted effect of trade on female labor force participation. The first potential strategy scrutinizes the micro patterns of labor migration in response to trade with Mexico and is based on firm- or plant-level data of trade, male and female employment. Lacking such data, however, we are forced to discard this option, which we leave for future work.

A second, alternative strategy is in the tradition of cross-country studies. It is motivated by the observation that our theory has ambiguous predictions for female labor force participation on the industry level, while its predictions are unambiguous on the aggregate country-level. Adapting this approach to the context of the NAFTA episode, we exploit the variation on the geographical or, more precisely, on the state level. Luckily, the geographical specificities suggest that labor markets of the different U.S. states should be impacted differently during the NAFTA episode. We thus can hope to find supportive evidence for our theory based on a relation between exposure to trade with Mexico and aggregate labor market outcomes on the state level. Doing so, we are fully aware of the fact that such a test can at best provide consistency for our theory at a rather broad level and we stress the appropriate disclaimer.

Concerning aggregate labor market outcomes, our theory predicts that, as a rich economy trades with a poor one, its female labor force participation decreases along with its female relative wage. When deciding whether to emphasize wages or employment in our empirical analysis, we notice that the empirical trade literature has documented an asymmetric impact of globalization on employment and wages. In particular, liberalization of goods markets appears to have a sizable effect on employment but a rather small effect on wages (Grossman 1987, Revenga 1992). This asymmetry may be a result of labor reallocation itself, which tends to erase wage differentials and mitigate wage effects. Alternatively, a selection bias problem

[31] Also, in an exercise very related to the present one, Juhn, Ujhelyi, and Villegas-Sanchez (2014) report that reallocation in the Mexican labor market during the NAFTA episode took place within industries.

blurs the impact of trade on wages as workers with specific characteristics systematically exit the labor market. Therefore, our empirical examination stresses the impact of exogenous change in trade on female labor force participation. However, to complete the picture, we also test for its impact on female relative wage.

3.2 Female labor force participation

3.2.1 The Empirical Model

In our empirical exercise, we concentrate on one side of our theory and aim to identify the effect of trade on the U.S. labor market (the capital rich economy). More precisely, we exploit the variation of U.S.-Mexican trade across different U.S. states to identify the differential impact of trade on female labor shares and female relative wage across states.[32]

According to our theory, a higher exposure to trade with Mexico induces lower female labor force participation in the different U.S. states. Put differently, our theory suggests that, other things being equal, a state that is exposed to a larger expansion in trade will experience a higher reduction in female labor force participation.

Analyzing this relation on the state level, our reduced form model takes the following form:

$$\Delta y_s = \alpha + \beta \Delta Trade_s + X_s' \gamma + u_s \tag{36}$$

where for any variable, z_s the s indicates the different U.S. states and Δ indicates the change over time - before and after NAFTA. The dependent variable y_s is one measure of labor force participation. We consider employment and weekly hours worked for both genders and

[32] The focus on U.S. states as economic entities may seem problematic since state borders are not relevant restrictions for the labor. This drawback, however, implies that inter-state labor migration can eliminate differences in the gender wage gap and female labor force participation across states, which tends to eliminate the differential effects of trade across states. Thus, no differential effect of trade on female labor shares across states can be expected as long as the U.S. labor market operates frictionless. Nevertheless, we expect to capture labor market effects to the extent that frictions of labor movement related to geographical distance impede a full equalization of factor prices across U.S. states.

female share in weekly hours worked. $Trade_s$ is trade volume per output. We control for a vector of covariates X_s' chosen by economic intuition but unrelated to our theoretical model. Our initial period is 1990-1, while the end period is 2006-7.[33] Our theory predicts that the estimate of β in (36) is negative.[34]

We first run an OLS regression of the type described in (36). However, labor market conditions in the U.S., reflected by higher shares of female labor, can constitute a form of comparative advantage and thus drive trade volumes. This edogeneity biases our OLS estimates and leaves us with the need to instrument so as to establish the desired causality.

We slightly modify the gravity equation of the trade literature and instrument $\Delta Trade_s$ by distance to Mexico.[35] Thus, our first stage regression is:

$$\Delta Trade_s = \mu + \theta \ d_s + X_s' \ \rho + \nu_s \tag{37}$$

where d_s is distance of state s to Mexico.

Figure 6 illustrates that distance is strongly correlated with the increase in trade share, thereby satisfying a first necessary condition for being a valid instrument.

Perhaps our instrument *distance to Mexico* has a direct effect on female labor force participation or is correlated with other relevant variables that have an effect on female labor force participation. Possible examples include development, culture or religiosity, which typically correlate with latitude. However, by taking first difference we eliminate the state-fixed effect. It still may be the case that distance is correlated with the pace at which female labor force participation changes. To verify this point, we perform the following additional falsification test. Using data from the pre-NAFTA period, we regress a reduced form model

[33]This time window is determined by availability of trade data. The data set includes entries for the years 1988/89 but these are of inferior quality.

[34]For summary statistics and data description see the data subsection and Table 7 in the Appendix. Broadly speaking, two observations can be drawn. First, while female labor force participation has increased, male labor force participation has decreased. Second, the hourly wage for both genders has increased during the period.

[35]More precisely, we regress trade volume as a percentage of Gross State Product on spherical distance of U.S. state capitals to Mexico City, while the standard gravity equation estimates the log of bilateral trade volume on the log of GDP, spherical distance and other variables.

of the change in female labor force participation on distance. We find supportive evidence for our presumption that only during the NAFTA period does distance positively impact the change in female labor force participation, which suggests that the exclusion restriction is likely to hold.[36] One may still argue that during the NAFTA period changes in female labor force participation were more prominent than during the pre-NAFTA period. As a result, we observe the correlation between distance and changes in female labor force participation only during the NAFTA period. Our presumption here is that culture and religiosity have not changed during the period 1960–2000 and therefore if these characteristics were to impact the correlation between distance and the pace at which female labor force participation changes during the 90s, there is no reason to think that these same characteristics had no such impact during the 60s. Moreover, looking at average female employment, it has increased during the pre-NAFTA period by about 20 percent (from 31.2 percent in 1960 to 37.4 percent in 1970) while it has increased during the NAFTA period by about 17 percent (from 54.4 percent in 1990 to 63.4 percent in 2000). This implies that the pace of change during the whole period was more or less the same.

The secular trend towards higher female labor force participation together with the fact that it is naturally bounded from above implies that female labor force participation converges across states. Hence, the initial level of female labor share is highly correlated with the change in female labor force participation. To account for this convergence effect, we include the initial level of female labor force participation in the controls when estimating (36). A problem with this control variable, however, is that it is correlated with the error term in (36), wherefore we instrument it with lagged female labor participation (values from 1980/81). We can quickly verify the first precondition for the instrument to be a valid one – i.e. a positive correlation of the levels in 1980 and 1990. According to our second assumption, the levels in 1980/81 affect the changes in female labor force participation during the

[36] Exact details about our falsification test are explained in the Appendix and its results are reported in Table 8.

period 1990/91–2006/7 only through the levels of 1990/91.[37]

3.2.2 Regression Results

With our model in mind, we focus in our baseline specification for women and men separately. We start by the extensive margin and define y_s as employment.

In all our specifications, labor force is defined as the total of individuals aged between 16 and 65, excluding members of the Armed Forces. We further define exposure to trade as twice the state exports to Mexico over GSP. We restrict the study to export because import data per state are not available.[38] Distance is defined as spherical distance from state capitals to Mexico City.

Table 2 reports the results of our baseline regression. Column 1 reports a simple OLS regression of our dependent variable: change in female employment. The coefficient of our main variable, ΔTrade with Mexico is negative and significant at the 5% level. Its magnitude implies that a 1 percent increase in trade shares is associated with a decrease in female employment by 0.8 percentage points. However, as discussed earlier, the OLS regression suffers from a bias due to endogeneity problems. E.g. higher female labor force

[37]This second assumption may appear controversial. To examine it, we briefly review a list of common determinants of female labor participation and discuss their respective potential to generate a correlation between female labor shares in 1980 and the growth of female labor shares between 1990/91 and 2006/07 other than through female labor shares in 1990. Frequently cited determinants are discrimination (Altonji and Blank 1999) or habits, beliefs and tradition (Hazan and Maoz 2002, Fogli and Veldkamp 2011, Fernández 2013). Indeed, traditions or discrimination in early periods might depress the female labor share, and subsequent erosion of them induces a rise in female labor shares. Notice, however, that in these models, when conditioning on the level in 1990, the level in 1980 has no explanatory power for growth subsequent to 1990 – which exactly reflects our second assumption. Other important determinants are related to technological progress. Recent studies mention classical technological progress as a driver of wage convergence between the sexes (Galor and Weil 1996). Other work stresses efficiency gains in the household sector (Greenwood, Seshadri, and Yorukoglu 2005, Cavalcanti and Tavares 2008) or the emergence of the child care sector, which frees women's time for labor participation (Hazan and Zoabi 2014). Others argue that progress in the medical sector can enable women to pursue formal careers (Goldin and Katz 2002). We notice, however, that technologies are uniformly accessible across the different U.S. states, so that corresponding effects should not impact our estimates. However, to the extent that technologies are adopted only sluggishly, a similar argument as the one made in connection with traditions may apply. Finally, we point out that reverse causality – higher female labor induces faster technological progress and wage convergence – would generate divergence in female labor shares. The data do not confirm such a pattern. Overall, we conclude that our assumption concerning the instrument appears sound.

[38]We assume that import equalizes export to obtain a coefficient of that is comparable with previous literature.

participation strengthens the comparative advantage in the capital-intensive sector, which generates higher international specialization and trade.

To avoid this endogeneity and to identify the causal relation running from change in trade to female employment, we conduct an IV regression, in which the change in trade is instrumented by distance. This regression is summarized in Column 2. Interestingly, the magnitude of the negative coefficient, which is significant at the one percent level, almost doubled (-1.5). In both regressions, however, the coefficient on the initial level of female employment is negative and significant, as generally implied by convergence.

Our theory suggests that trade-induced specialization reduces female labor force participation in the capital-rich country while making male workers merely change sectors. The summary statistics in Table 7 show that average employment has slightly increased from 65% to 67% for women while it has slightly declined from 78% to 77% for men. Thus, we repeat the same regressions for male workers and their results are summarized in Columns 3 and 4 of Table 2. Both, the OLS and IV estimates are not different from zero.

To eliminate labor market shocks that are common to both genders, we define in Columns 5 and 6 female labor force participation as the share of female employment out of total employment. As expected, the results of the OLS and IV verify what we saw earlier that trade expansion had a negative impact on female employment relative to male.

Another interesting measure of labor force participation is the weekly hours worked. This measure uncovers the intensive margin as well and may be informative. All the specifications of Table 2 are repeated in Table 3 when the dependent variable is weekly hours worked. The summary statistics in Table 7 shows that Average female hours per week were 22.77 (standard deviation across states is 1.92) in 1990/1991 and 24.24 (1.84) in 2006/2007. The corresponding numbers for males are 32.92 (1.89) and 32.2 (1.81), respectively. Thus these numbers suggest that while average weekly hours worked had risen for women, there was a slight drop for men.

The regression results, However, show that the general picture is similar to the one drawn from Table 2. The first two columns focus on women and show that both the OLS and IV coefficients are negative and significant and so is the one on the initial level of female hours worked. Still, the OLS coefficient is biased towards zero. One noticeable difference from Table 2, however, is revealed in Column 4, which shows that trade had a positive impact on men's weekly hours worked. At first glance, one may think that this contradicts our model's results. Recall that our model assumes inelastic male labor supply. The decline in female labor hours driven by households' choice is a reflection of a reduction in women's relative productivity, which corresponds to an increase in men's relative productivity. Consequently, allowing elastic male labor supply in our model yields an increase in men's working hours as suggested in Column 4 of Table 3. We define in Columns 5 and 6 female labor participation as the share of female hours out of total weekly hours worked. Again the coefficients have the expected signs, magnitudes and significance. With this latest measure of female labor force participation, we proceed with some robustness checks.[39]

3.2.3 Robustness

We next conduct some robustness checks for the results obtained in the baseline regression. We take female share in weekly hours worked as our measure of female labor force participation. Thus our regressions below correspond to the one summarized in Column 6 of Table 3. First, we exclude Texas, Alaska and Hawaii and the three states altogether from the sample since these states appear to be outliers in terms of distance and the predicted trade shares (see Figure 6). Table 4 summarizes the corresponding results in the first three columns. Although Texas seems to affect the magnitude of the coefficients, the exclusions of these states do not alter the general picture: the impact of trade share with Mexico remains negative and significant at the 1% confidence level (5% in Column 3).

We are also concerned about our definition of trade shares, since Cassey (2009) reports

[39]We also control for change in gross state product, change in unemployment and change in women's education or total education. The results, which is not reported here, show that the inclusion of these control variables does not affect neither the magnitude nor the significance of our main variable Saure and Zoabi (2009).

that export data exhibit systematic differences between 'origin of movement definition' and 'origin of production'. Since these errors are substantial in the agricultural and mining sectors only, we replace total export over GSP per state by the according manufacturing export percentages. Column 4 in Table 4 shows that our concerns are unsubstantiated: the estimates are still significant at the 1% level and estimated magnitudes are very similar.

In trade literature, the standard measure for distance is the spherical one (spherical distance between capitals). However, since the U.S. and Mexico have common borders, we check whether our results depend on the choice of distance and replace it by ground distance to the Mexican border. Column 5 in Table 4 shows that our results are intact.[40]

Since our theory rests on intra household optimization, it seems appropriate to restrict our sample to married individuals only. Column 6 in Table 4 shows that neither the point estimates nor the significance level are affected.[41]

Next, we conduct the same regression in Column 6 of Table 3 but without state weights. In this regression we give the same weight for all states and actually examine the impact of trade expansion at the state level rather than the individual level. Still, the coefficient is negative and significant at the 1% level.

Finally, if women are more employed in unskilled intensive sectors in the South than the North, then the standard skilled-unskilled Hecksher-Ohlin model may also explain the observed differential impact of trade on female employment that is correlated with distance through importing unskilled-intensive goods from Mexico. To investigate this option, we repeat the baseline regression while focusing on three different education groups: 'less than high school', 'high school graduate' and 'advanced education'. Interestingly, Table 5 shows

[40] Ground distance is measured in time and derived from maps.google.com.

[41] Another relevant concern is the influence of immigration from Mexico. Quite obviously distance to Mexico can impact labor market conditions of a state via the share of Mexicans workers. On the one hand, assuming that Mexican women work less than native American along with the nonproportional flows of immigrants to the American South may explain our results. On the other hand, the nonproportional flows of immigrants to the American South may increase female labor force participation of Native American as these immigrants may serve as a substitute for women's time at home, inducing them to work more (Cortes and Tessada 2011, Hazan and Zoabi 2014). Thus, we check the impact of change in trade on female labor force participation for native born only. The estimate, which is not reported, is still negative and significant as predicted.

that the negative impact of trade on female labor share applies to all three education groups with a smaller impact for more educated women.

3.3 Female Relative Wage

3.3.1 The Empirical Model

Since our mechanism suggests that trade and specialization affect female labor force participation through women's relative wages, we would like to empirically examine whether U.S. trade with Mexico had the expected impact on the relative wages of U.S. women. Although consensus exists in the literature that the impact of trade on wages is very weak we seek to investigate whether higher trade with Mexico has an impact on the relative wage of U.S. women and whether this impact has the expected sign.

According to our theory, a higher exposure to trade with Mexico induces lower female relative wage in the different U.S. states. Put differently, our theory suggests that, other things being equal, a state that is subject to higher expansion in trade with Mexico will experience a larger decrease in female relative wage.

Following the specification in (36), we analyze the relative wage at the state level with the following empirical model

$$\Delta \left(\frac{w^f}{w^m} \right)_s = \alpha' + \beta' \Delta Trade_s + X_s' \gamma' + v_s \tag{38}$$

The dependent variable $\Delta(\frac{w^f}{w^m})_s$ is the change in the relative wage of women in state s. We keep the same notation of section 3.2. Our theory predicts that the estimate of β' in (38) is negative. Again, our first stage regression is the same as in (37). We control for the initial level of relative wage, and in order to avoid its correlation with the error term in (38), we instrument it with a lagged female relative wage (values from 1980/81).

3.3.2 Regression Results

Table 6 reports the results of our regression. Column 1 reports an IV regression of our dependent variable: change in female relative wage. However, as described in the introduction, Mulligan and Rubinstein (2008) find that the selection of women into the labor market during the 1990s was positive, which implies that mainly the less able women, *i.e.* those with the lower wages, tend to leave the labor market due to the negative shock to wages driven by international trade. As a result, the average wage increases, which per se might cancel out the negative impact of trade on wages. Put differently, the measured average wages of working women don't change, while the unmeasured potential wages of nonworking women decrease, so that the change in the measured average wage for working women doesn't reveal the full impact of NAFTA. Indeed, Column (1) in Table 6 shows that β' is not significantly different from zero.

To correct for the positive selection bias, we define the wage to be zero for all individuals who don't have a wage income in our data. Doing so, we preserve the full sample throughout our analysis. The shares of imputed zero wages vary over time and across states. These shares are $37\% - 55\%$ for women and $43\% - 64\%$ for men. We then estimate the model from (38), where the dependent variable is now defined via wages at the different percentiles of the wage distribution. Columns (2)-(5) in Table 6 show that, overall, the estimates are negative and, in the case of 90^{th} and 85^{th} percentiles, significant. Two observations are in order. First, the different percentiles chosen cover almost the whole distribution of the working sample. Second, the negative impact of trade on wages is stronger for higher percentiles of the wage distribution. This latter observation is consistent with the view that women who are endowed with relatively high mental labor are those whose wages are negatively affected by trade.

4 Concluding Remarks

The impact of trade on female labor force participation has recently attracted the attention of academic economists and policy makers. For example, the World Bank's *World Development Report 2012* states that "trade openness and the diffusion of new information [...] technologies have translated into more jobs and stronger connections to markets for women, increasing their access to economic opportunities and contributing to their economic empowerment." This statement echoes an early argument by Becker (1971), who argues that international trade increases competition among firms, and, by reducing costly discrimination, thereby closes the gender wage gap and fosters female labor force participation. Recently, studies also explore other channels through which trade impacts the integration of women in the labor market, typically stressing the following intuitive mechanism: when trade expands a country's sectors with high female labor shares, its aggregate female labor force participation should increase.

The current paper challenges this view by arguing that as trade expands female intensive sectors, the gender wage gap may actually widen, inducing female labor force participation to fall. Our theory builds on the asymmetric complementarity between capital and female labor on the one hand and capital and male labor on the other hand. Assuming, in particular, a relatively strong complementarity between capital and female labor gives rise to our main, counterintuitive result. Since the female intensive sector is also capital intensive, trade integration of a capital-abundant economy brings about an expansion in the female intensive sector and a contraction in the male intensive sector. As a result, male labor reallocates from the contracting sector to the expanding one. This migration dilutes the capital labor ratio in the female intensive sector. The relatively strong complementarity between capital and female labor causes the marginal productivity of women to drop more than that of men. Thus, the gender wage gap widens and female labor force participation falls.

We test our theory using bilateral trade data for the U.S. and Mexico. We exploit U.S. cross-state variation in the exposure to trade with Mexico to examine how trade has impacted female labor force participation and female relative wage. Our cross-state regressions suggest that, in rich economies, international trade with poor countries tends to increase the gender wage gap and reduce female labor force participation. We acknowledge that the patterns presented in our empirical section support our theory at a rather broad level and that future empirical work might analyze the presented mechanism in more detail. Based on disaggregated employment data, such an analysis should show how import penetration, when driven by capital intensity, causes reallocation of male workers and the predicted replacement between male and female workers in capital intensive sectors.

Finally, we stress that the theoretical mechanism described in this paper may generalize in various directions. Thus, our model, read as a general 2-good 3-factor setup, can potentially be applied to other factors and factor prices, for which the respective complementarity conditions apply. Moreover, it can be shown that the key mechanism also applies in the case when technological progress is biased towards the female intensive sector. By increasing wages in that sector, such technological progress attracts male workers to the female intensive sector. The resulting dilution of capital per worker can be strong enough to drive female workers out of formal employment. In this way, technological progress, biased towards sectors of relative female advantage, might curb female labor force participation.

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Figures & Tables

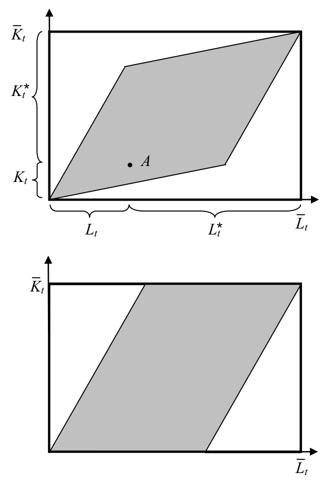


Figure 1: Factor Price Equalization Set

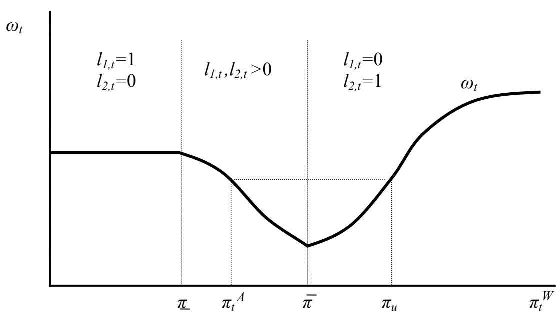


Figure 2: Gender Wage Gap and World Price

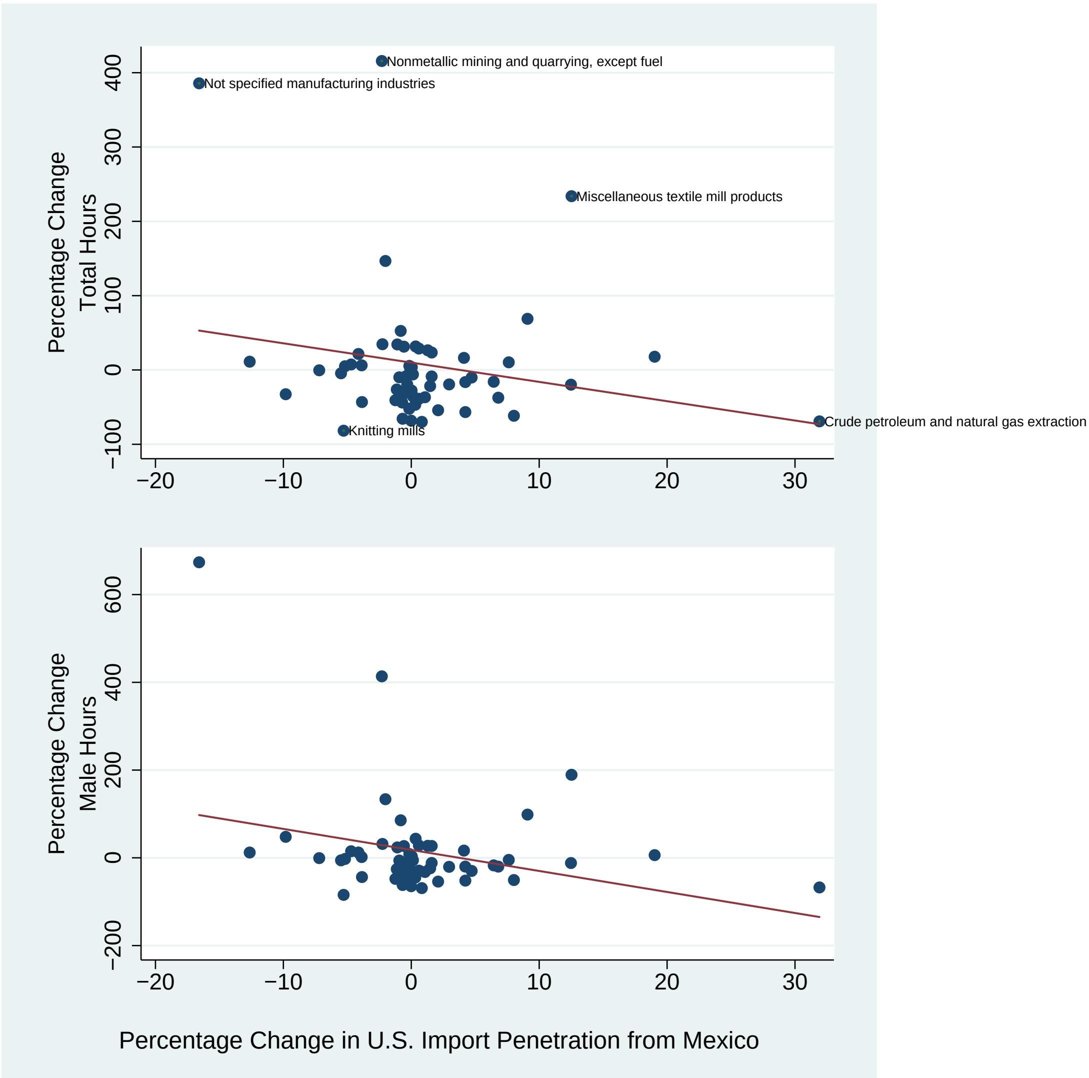


Figure 3: Percentage change in U.S. employment (measured in total hours worked) against the increases in bilateral import penetration from Mexico (defined as changes of real value of net imports over the wage bill in the initial period) during the period 1990-2007. Source: Trade data are from United States Import And Export Data (available at http://cid.econ.ucdavis.edu/) and employment data are from IPUMS-CPS.

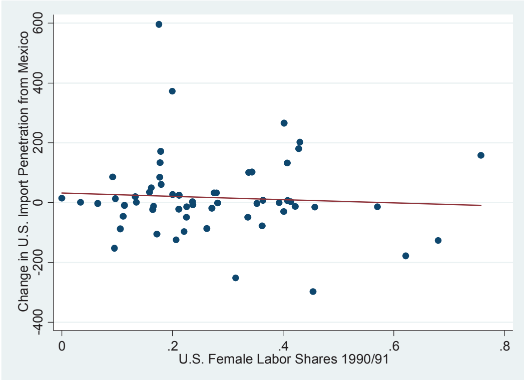


Figure 4: U.S. female labor shares in 1990/91 (measured in total hours worked) against the increases in bilateral import penetration from Mexico (defined as changes of real value of net imports over the wage bill in the initial period) during the period 1990-2007. Source: Trade data are from United States Import And Export Data (available at http://cid.econ.ucdavis.edu/) and employment data are from IPUMS-CPS.

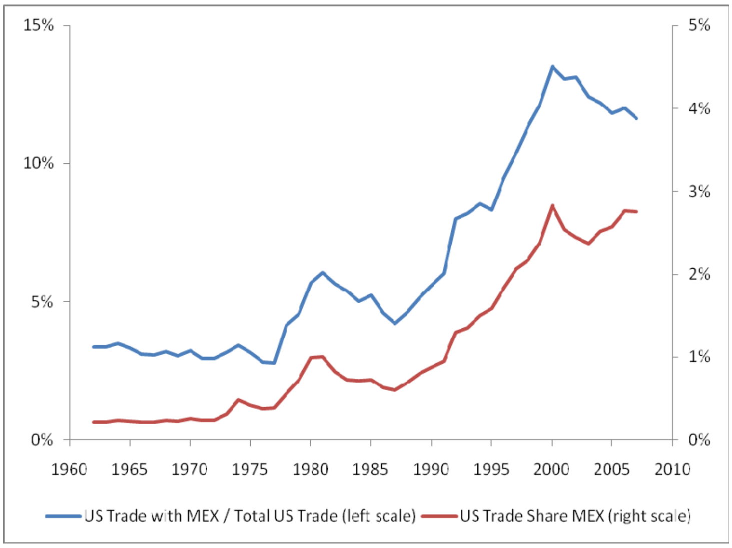
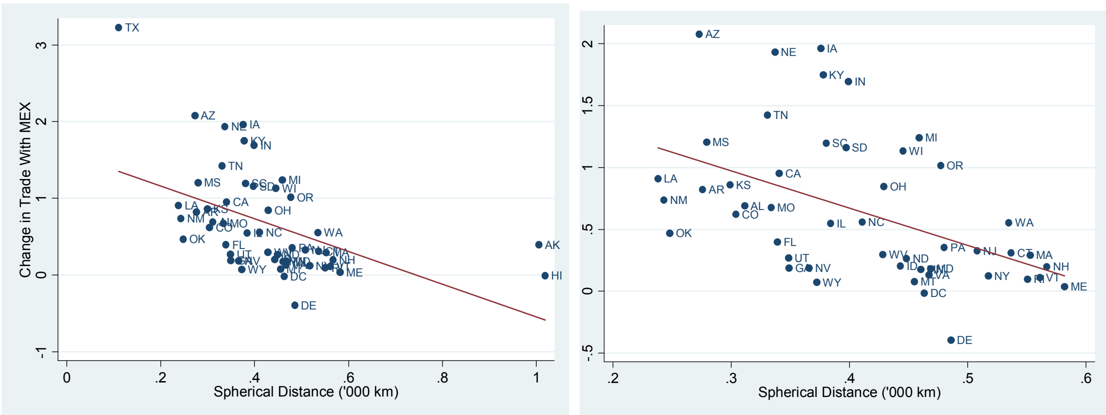


Figure 5: U.S. Trade Share – Imports plus Exports over GDP – with Mexico (red line, right scale) and Mexico's Share of U.S. Trade Volumes (blue line, left scale). Source: (1) Nominal GDP: are from Heston, Summers, and Aten (2006) and (2) US imports from and export to Mexico are from Feenstra, Lipsey, Deng, Ma, and Mo (2005) for the period 1962 - 2000 and from United States International Trade Commission for the period 2001 - 2008



slope = -2.13 t-statistic= -3.92

slope = -3 t-statistic= -3.75

Figure 6: Change in Trade with Mexico by State (1990-2007). left Panel: all states; right panel: excluding Alaska, Hawaii and Texas.

Table 1: The Change in U.S. Import Penetration from Mexico vs. Change of U.S. Employment for Women and Men During the Period 1990/91–2006/07

	Dependent Variable: Percentage change in total hours worked for					
	All	Male	Female	All	Male	Female
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Δ Import Penetration	−2.597 (1.691)	-4.791^{**} (2.088)	−0.996 (1.711)			
Δ Residual				-3.445^{*} (1.731)	-5.626^{**} (2.138)	−1.910 (1.762)
Constant	9.938 (11.84)	18.02 (14.63)	10.18 (11.98)	7.605 (11.59)	13.71 (14.31)	9.285 (11.80)
Obs	58	58	58	58	58	58
R^2-Adjusted	0.0233	0.0696	-0.0117	0.0494	0.0942	0.00306

NOTE.-Standard errors adjusted for heteroscedasticity are reported in parentheses. Percentage change in U.S. employment (measured in total hours worked) against the increases in bilateral import penetration from Mexico (defined as changes of real value of net imports over the wage bill in the initial period) during the period 1990-2007. Source: Trade data are from United States Import And Export Data (available at http://cid.econ.ucdavis.edu/) and employment data are from IPUMS-CPS.

Table 2: The Effect of U.S. Trade with Mexico on U.S. Female and Male Employment Rate during the period 1990/91–2006/07

	Dependent Variable: Change in LFP defined as employment rate					
	Female		Male		Share of Female	
	OLS (1)	IV (2)	OLS (3)	IV (4)	OLS (5)	IV (6)
Δ Trade	−0.814** (0.332)	−1.544*** (0.495)	−0.001 (0.288)	0.500 (0.319)	−0.482*** (0.171)	−1.275** (0.543)
LFP 80/81	−0.345*** (0.070)		0.043 (0.073)		−0.390*** (0.115)	
LFP 90/91		−0.385*** (0.079)		0.006 (0.093)		−0.920*** (0.377)
		First-Stage Coefficients (Dependent Variable: Δ Trade)				
Distance		−4.738*** (0.671)		−4.597*** (0.712)		−4.631*** (0.711)
LFP 80/81		−0.001 (0.021)		0.016 (0.027)		−0.032 (0.072)
Joint F-Stat		25.02		25.36		25.22
		First-Stage Coefficients (Dependent Variable: FLFP in 1990/91)				
Distance		8.076** (3.244)		5.577*** (1.824)		2.564** (1.270)
LFP 80/81		0.899*** (0.104)		0.816*** (0.070)		0.501*** (0.129)
Joint F-Stat		41.86		68.45		13.87
Obs	51	51	51	51	51	51

Note.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. States are weighted by population size. In the bottom part of the table the first stage coefficients and the F-Statistic for the joint significance of the instruments are reported. See the Appendix for additional sample details and variable definitions.

Table 3: The Effect of U.S. Trade with Mexico on U.S. Female and Male Weekly Working Hours during the period 1990/91–2006/07

	Dependent Variable: Change in LFP defined as weekly working hours					
	Female		Male		Share of Female	
	OLS (1)	IV (2)	OLS (3)	IV (4)	OLS (5)	IV (6)
Δ Trade	-0.395^{**} (0.114)	-0.654^{***} (0.165)	-0.010 (0.141)	0.394^{**} (0.174)	-0.530^{***} (0.129)	-1.174^{***} (0.337)
LFP 80/81	-0.381^{***} (0.067)		-0.108 (0.068)		-0.398^{***} (0.068)	
LFP 90/91		-0.415^{***} (0.074)		-0.235^{**} (0.092)		-0.908^{***} (0.232)
		First-Stage Coefficients (Dependent Variable: Δ Trade)				
Distance		-4.785^{***} (0.682)		-4.559^{***} (0.707)		-4.718^{***} (0.665)
LFP 80/81		-0.021 (0.060)		0.039 (0.052)		-0.048 (0.053)
Joint F-Stat		25.13		25.6		25.85
		First-Stage Coefficients (Dependent Variable: FLFP in 1990/91)				
Distance		2.917^{**} (1.317)		2.692^{**} (1.059)		1.399 (1.038)
LFP 80/81		0.930^{***} (0.116)		0.788^{***} (0.078)		0.477^{***} (0.082)
Joint F-Stat		32.29		51.94		17.97
Obs	51	51	51	51	51	51

NOTE.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. States are weighted by population size. In the bottom part of the table the first stage coefficients and the F-Statistic for the joint significance of the instruments are reported. See the Appendix for additional sample details and variable definitions.

Table 4: The Effect of U.S. Trade with Mexico on U.S. Female Labor Force Participation

Dependent Variable:	Change in FLFP defined as women's share in weekly working hours						
	Excluding			Trade in	Distance	Married	Without State
	TX	Hi&AK	TX, HI&AK	Manufacture	in minutes	Couples	Weights
	IV	IV	IV	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Trade with Mexico	-2.191^{***}	-1.120^{***}	-2.084^{**}	-1.184^{***}	-1.410^{***}	-1.098^{***}	-1.506^{***}
	(0.764)	(0.310)	(0.816)	(0.361)	(0.534)	(0.241)	(0.420)
FLFP in 1990/91	-0.962^{***}	-0.929^{***}	-0.969^{***}	-0.881^{***}	-0.960^{***}	-0.632^{***}	-0.635^{***}
	(0.275)	(0.236)	(0.269)	(0.220)	(0.271)	(0.170)	(0.157)
	First-Stage Coefficients (Dependent Variable: Δ Trade)						
Distance	-2.297^{***}	-5.518^{***}	-2.896^{***}	-4.643^{***}	-0.001^{***}	-4.820^{***}	-2.021^{***}
	(0.658)	(0.689)	(0.770)	(0.666)	(0.000)	(0.669)	(0.581)
Joint F-Stat	6.48	32.69	7.33	24.74	18.11	25.97	7.76
	First-Stage Coefficients (Dependent Variable: FLFP in 1990/91)						
FLFP in 1980/81	0.480^{***}	0.508^{***}	0.523^{***}	0.477^{***}	0.538^{***}	0.532^{***}	0.529^{***}
	(0.083)	(0.084)	(0.084)	(0.082)	(0.078)	(0.093)	(0.066)
Joint F-Stat	17.78	19.48	20.58	17.97	26.94	16.62	35.01
Number of obs	50	49	48	51	51	51	51

NOTE.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. All regressions are conducted according to the model described in Column 6 in Table 3. For the first stage regressions we report only the relevant instrument and the F-Statistic for the joint significance of the instruments. See the Appendix for additional sample details and variable definitions.

Table 5: The effect of U.S. trade with Mexico on U.S. Females Labor Force Participation by skill level

	Dependent Variable: Change in FLFP defined as women's share in weekly working hours					
	Low education		Medium education		High education	
State Weight		+		+		+
	IV (1)	IV (2)	IV (3)	IV (4)	IV (5)	IV (6)
Δ Trade with Mexico	-6.034^{**} (2.667)	-3.578^{**} (1.426)	-1.136^{*} (0.579)	-1.140^{**} (0.445)	-0.964^{**} (0.450)	-0.528^{**} (0.243)
FLFP in 1990/91	-1.058^{***} (0.251)	-0.942^{***} (0.239)	-0.322^{*} (0.173)	-0.670^{**} (0.305)	-0.322 (0.195)	-0.400 (0.346)
	First-Stage Coefficients (Dependent Variable: Δ Trade)					
Distance	-2.170^{***} (0.604)	-4.776^{***} (0.682)	-2.085^{***} (0.555)	-4.854^{***} (0.664)	-2.073^{***} (0.561)	-4.777 (0.669)
Joint F-Stat	7.55	25.10	7.73	26.83	7.71	25.48
	First-Stage Coefficients (Dependent Variable: LFP in 1990/91)					
FLFP in 1980/81	0.728^{***} (0.152)	0.981^{***} (0.170)	0.463^{***} (0.084)	0.526^{***} (0.092)	0.414^{***} (0.077)	0.326^{***} (0.103)
Joint F-Stat	12.58	19.40	16.55	16.92	14.72	5.07
Number of obs	51	51	51	51	51	51

NOTE.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. All regressions are conducted according to the model described in Column 6 in Table 3. We define three categories of education: Less than high school, high school graduate and some college and above, which corresponds to low, medium and high educational levels. Regressions described in Columns 2, 4 and 6 are weighted by state population size. For the first stage regressions we report only the relevant instrument and the F-Statistic for the joint significance of the instruments. See the Appendix for additional sample details and variable definitions.

Table 6: The Effect of U.S. Trade with Mexico on U.S. Women's Relative Hourly Wage: (w^f/w^m)

Dependent Variable	Female wage over male based on:				
	Average Wage	Wage from the following percentiles			
		90^{th}	85^{th}	80^{th}	70^{th}
	IV (1)	IV (2)	IV (3)	IV (4)	IV (5)
Δ Trade with Mexico	0.002 (0.024)	-0.047^{**} (0.018)	-0.036^{**} (0.014)	-0.013 (0.015)	-0.015 (0.010)
w^f/w^m in 1990/91	-0.261 (0.702)	-0.668^{*} (0.349)	-0.659^{***} (0.206)	-0.470^{**} (0.207)	-0.16 (0.151)
	First-Stage Coefficients (Dependent Variable: Δ Trade)				
Distance	-2.135^{***} (0.549)	-2.097^{***} (0.574)	-2.030^{***} (0.578)	-2.032^{***} (0.565)	-2.060^{***} (0.551)
Joint F-Stat	7.57	7.57	7.75	7.88	8.10
	First-Stage Coefficients (Dependent Variable: w^f/w^m in 1990/91)				
w^f/w^m in 1980/81	0.496^{***} (0.157)	0.418^{***} (0.106)	0.665^{***} (0.117)	0.694^{***} (0.109)	0.654^{***} (0.087)
Joint F-Stat	5.55	8.51	16.68	20.56	29.32
Number of obs	51	51	51	51	51

NOTE.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. The independent variables are instrumented by distance and the according relative women's wage 1980/81. For the first stage regressions we report only the relevant instrument. See the Appendix for additional sample details and variable definitions.

Appendix

Proofs

Proof of Proposition 1. The proof of "$\Rightarrow$" is immediate by $r_t = r_t^*$ and (9).

For "$\Leftarrow$" assume that $\kappa_t^* = \kappa_t$, which implies $r_t = p_{1,t}\alpha a \kappa_t^{\alpha-1} = p_{1,t}\alpha a \left(\kappa_t^*\right)^{\alpha-1} = r_t^*$ and $w_t^F = p_{1,t}(1-\alpha)a\kappa_t^{\alpha} = p_{1,t}(1-\alpha)a\left(\kappa_t^*\right)^{\alpha} = w_t^{F,*}$. By $X_{2,t} > 0$ we have $l_{2,t} + l_{2,t}^* > 0$. In case $l_{2,t}^*, l_{2,t} > 0$ $w_t^M = w_t^{M,*}$ follows from (10). In case $l_{2,t}^* = 0$ this implies

$$w_t^M = p_{2,t}b \leq w_t^{M,*}.$$

At the same time $l_{1,t}^* = 1$ implies

$$w_t^{M,*} = p_{1,t}((1-\alpha)a(\kappa_t^*)^{\alpha} + b) = p_{1,t}((1-\alpha)a\kappa_t^{\alpha} + b) \leq w_t^M$$

so that $w_t^M = w_t^{M,*}$. In case $l_{2,t} = 0$ switching Home and Foreign variables leads to $w_t^M = w_t^{M,*}$ again. ■

Data

We rely on three different data sources. First, we use is the March Current Population Survey conducted by the Integrated Public Use Microdata Series (IPUMS-CPS).[42] From IPUMS-CPS we take the variables age, sex, marital status, population status (to distinguish between civilian or Armed Forces), nativity (to identify native American), location (state), educational attainment, employment status (to compute the formal employment share) weeks worked, usual hours worked (to compute total hours worked) and wage and salary income (to compute hourly wage). The second database we use is the 'Origin of Movement' administered by WISER,[43] which covers export data by state and destination country from 1988 onward. These data are disaggregated by goods categories (SIC from 1988 to 2000; NAICS from 1997 onward). Third, we use the Bureau of Economic Analysis for GDP data on the state level.[44] Table 7 below provides some characteristics of the U.S. data for the initial and ending periods: 1990/91 and 2006/07.

[42] King, Ruggles, Alexander, Flood, Genadek, Schroeder, Trampe, and Vick (2010).

[43] World Institute for Strategic Economic Research; data available under http://www.wisertrade.org. Cassey (2009) gives a good introduction to the data and their limitations.

[44] Data available under http: http://bea.doc.gov/regional/.

Table 7: Characteristics of U.S. Data, 1990/91 and 2006/07

	1990/91	2006/07
FEMALE		
Education (%)	39.38 (5.59)	56.55 (5.36)
Weekly hours worked	22.77 (1.92)	24.24 (1.84)
Hourly wage	11.39 (1.65)	14.55 (2.22)
Employment (%)	65 (5.2)	67 (4.7)
MALE		
Education (%)	41.21 (6.36)	50.87 (5.92)
Weekly hours worked	32.92 (1.89)	32.2 (1.81)
Hourly wage	15.84 (2.02)	19.14 (3.24)
Employment (%)	78 (3.6)	77 (4.2)
State		
per-capita GSP	28321 (11307)	37968 (13881)
Trade share (%)	0.53 (0.98)	1.21 (1.51)
Unemployment (%)	6.34 (1.36)	4.82 (1.09)

NOTE.-Gross state standard deviations are in parentheses. Data for education, labor participation, wages and Mexican immigrants are from IPUMS-CPS, data for trade are from World Institute for Strategic Economic Research and data for Gross State Product are from the Bureau of Economic Analysis. State Education rate is measured by the share of civilians aged 16–65 that have, at least, some college education. Employment is the share of individuals reported working out of the population aged 16–65. Per capita Gross State Product data are chained 2000 dollars. Trade share data are calculated as two fold export volumes over GSP. Census sample weights are used for all calculations.

A Falsification Test

In our falsification test we conduct the following triple difference exercise. We compare the explanatory power of distance to Mexico for the change in female labor force participation in two different periods: first, 1990–2000, in which we observe a substantial increase in U.S.-Mexican trade; and second, 1960–1970, when U.S.-Mexican trade was stagnant (Figure 5). We simply label these periods by "NAFTA episode" and "pre-NAFTA episode" respectively. We employ the Integrated Public Use Microdata Series (IPUMS-USA) of the decennial censuses data (Ruggles, Sobek, Alexander, Fitch, Goeken, Kelly Hall, King, and Ronnander (2009)). This source provides us with employment data for men and women for the years 1950, 1960 and 1970 for the pre-NAFTA episode, and 1980, 1990 and 2000 for the NAFTA episode. Table 8 below summarizes these reduced form regressions of the change in female labor force participation directly on distance in the two episodes and shows that during the NAFTA episode the coefficients of distance are positive and significant while in the pre-NAFTA episode are negative and not consistently significant. We read this as additional support to the validity of our instrument.

Table 8: Explanatory Power of Distance on Female Labor Force Participation

Dependent Variable: Change in FLFP Defined as	Share of Hours Worked		Relative Employment	
	pre NAFTA	NAFTA	pre NAFTA	NAFTA
	(1)	(2)	(3)	(4)
distance	-3.933^{***}	2.703^{***}	-4.423	10.236^{***}
	(1.44)	(0.562)	(4.572)	(1.844)
Initial FLFP	-0.009	-0.544^{***}	-0.217	-0.736^{***}
	(0.111)	(0.08)	(0.134)	(0.125)
	First-Stage Coefficients (Dependent Variable: Initial level for FLFP)			
Lagged FLFP	0.675^{***}	0.593^{***}	0.753^{***}	0.632^{***}
	(0.085)	(0.039)	(0.047)	(0.068)
Number of obs	42	51	42	51

Note.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. In all regressions FLFP is regressed on distance and the initial level of FLFP. The dependent variables, relative employment described in Columns 3 & 4 is the ratio of women employment over males employment. The initial level of FLFP is instrumented by its lagged level. The pre-NAFTA period is 1960–1970 and the NAFTA period is 1990–2000. Lagged levels are 1950 and 1980, respectively. For the pre-NAFTA period part of the data are missing for 9 states, which are Alaska, Delaware, Hawaii, Idaho, Montana, North Dakota, South Dakota, Vermont and Wyoming. Restricting our NAFTA period regressions to the same 42 states does not affect neither the magnitudes of coefficients nor their significance. See the note to Table 7 for additional sample details and variable definition.