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

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Abstract

This paper argues that whenever trade expands sectors intensive in female labor, the gender wage gap widens and female labor force participation (FLFP) falls. We distinguish between a female intensive sector (FIS) and a corresponding male intensive sector (MIS). Since the FIS is also capital intensive, trade integration of a capital-abundant economy brings about an expansion in the FIS and a contraction in the MIS. This induces a factor reallocation, consisting mainly of male labor, from the MIS to the FIS. This factor reallocation dilutes the capital labor ratio in the latter sector. The relatively high complementarity between capital and female labor causes the marginal productivity of females to drop more than that of males, the gender wage gap widens and FLFP falls. We provide empirical evidence on U.S.-Mexican trade flows that supports our theory.

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

JEL Classifications: F10, F16, J13, J16.
1 Introduction

The causes and consequences of female labor force participation and trade integration are two major research areas in economics. While research abounds on either of these research areas separately, the literature addressing the interplay between them remains strikingly scarce. This paper provides an empirical and a theoretical study of how international trade, by affecting demand for male and female labor, impacts the gender wage gap and thus female labor force participation. Surprisingly, our theory suggests that when trade expands sectors intensive in female labor, aggregate female labor shares drop.

Our theory builds on the model developed in Galor and Weil (1996). As in this earlier work, female labor and male labor are imperfect substitutes, which makes them two distinct factors of production. 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. The preference structure implies that households split their time between child-rearing and formal employment. Households’ optimization, however, requires that females raise children, while males are always fully employed. Finally, female labor supply increases as the gender wage gap closes, but is independent of the level of real wage 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

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1Acemoglu, 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 females’ and males’ wages. They find that a 10% increase in female labor input decreases females’ wages by about 7% – 8%, but reduces males’ 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.

2Goldin (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.

3Goldin (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 (2006) find a negative causal effect running from fertility to female labor force participation.
intensive sector and the corresponding male intensive sector. 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 is 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. Therefore, for a capital-abundant economy, trade brings about an increase in the price of the good produced in the female intensive sector. 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 factors reallocation comprises more labor relative to capital, which dilutes the capital intensity in the female-intensive sector. Hence, the relatively high complementarity between capital and female labor causes the marginal productivity of females to drop more than that of males, the gender wage gap widens and female labor force participation falls.

Our theory generates the following testable predictions: when trading with a poor, capital scarce economy, trade decreases female labor force participation and female relative wage in the rich economy. To test these predictions we use bilateral trade data for the U.S. (the

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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.

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.
capital rich economy) and Mexico (the capital scarce economy). Central to our estimation strategy are the differences between U.S. states in terms of their increase of trade with Mexico during the period 1990-2007. 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.

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. Consistent with our theory’s predictions, the analysis reveals statistically significant negative impacts of trade 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 female hours worked as a share of total hours worked or, alternatively, as female employment as a share of total employment. We find that changes in trade shares – instrumented by geographical distance – have negative and significant impacts on both measures of female labor force participation. Importantly, our results remain robust to 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 and female labor separately and find support for this prediction. Finally, to eliminate the possibility that the estimated effects are driven by the low-skill sectors only, we limit our sample to highly educated individuals and find that our results still hold.

Moving to the effects of trade on female relative wage, we define the dependent variable in our regressions as the ratio between females’ average wage to males’ average wage. Mulligan

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7 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.

8 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.

9 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.
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 the 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 negative 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.

A brief explanation of our empirical strategy seems appropriate. One may argue that focusing on aggregate female labor is not the most direct way to test our theory but rather examining the reallocations of male and female labor across sectors. However, two crucial reasons dictate our choice. First, our predictions regarding female labor participation concern aggregate female labor but do not apply at the industry-, firm- or plant-level. Specifically, female workers, laid off in the shrinking sector, may partly return to home production and partly migrate to the expanding sector, so that female labor in the expanding sector rises (Sauré and Zoabi 2011). Our theory thus predicts that female labor drops in the contracting sector and in aggregate. Testing its decrease in the contracting sector is hardly supportive to our theory and therefore, we test the aggregate decline. The second reason for our empirical strategy is the following: 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.

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). Moving to understanding the gender wage gap, our paper is related to a different body of literature that explains the transition in the gender wage gap (Welch 2000, Gosling 2003, Black and Spitz-Oener 2010). Our modeling setup corresponds to this literature by taking primary attributes as the source of the gender wage gap.

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 reduces costly discrimination and closes 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, the North American Free Trade Agreement (NAFTA) increased employment of Mexican women and thus their bargaining power within the households. This finding is consistent with our theory and, by concentrating on the effects of NAFTA for Mexican women, constitutes the mirror image of our empirical findings. To analyze the increase in female employment in Mexico, Juhn, Ujhelyi, and Villegas-Sanchez (2012) argue that trade liberalization causes some firms to start exporting and adopting modern technologies that induces 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 males’ and
females’ employment and wages decreased but that these changes were more pronounced for females. 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.\footnote{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 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.

\section{The Model}

In our modeling strategy we follow Galor and Weil (1996) by adopting a standard OLG model, incorporating the endogenous choice of fertility.\footnote{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.} 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 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:

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

$$X_{1,t} = a K_t^\alpha (L^m_t)^{1-\alpha} + b L^p_{1,t}$$

$$X_{2,t} = b L^p_{2,t}. \hspace{1cm} (2)$$

The variables $L^p_{i,t}$ stand for the physical labor employed in sector $i$ at time $t$, while $L^m_t$ is the amount of mental labor in the first sector at time $t$. \hspace{1cm} (12)

\text{Examples of $X_2$ production are agriculture, mining or construction if production is conducted in the traditional way. As for $X_1$ 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 in highly skilled occupations.}
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:

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

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 cost of a child is $zw_t^M$.

\[\text{Note that since the basic unit is a household which consists a husband and wife, } n_t \text{ is, in fact, the number of pairs of children that a couple has.}\]
cost of a child is $zw_t^M$. The household’s budget constraint is therefore

\begin{align}
    w_t^F zn_t + s_t & \leq w_t^M + w_t^F \quad \text{if} \quad zn_t \leq 1 \\
    w_t^F + w_t^M (zn_t - 1) + s_t & \leq w_t^M + w_t^F \quad \text{if} \quad zn_t > 1
\end{align}

(4)

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

\[ c_{t+1} = s_t (1 + r_{t+1}) \]

(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:

\[ k_t = K_t / L_t \quad m_t = L_t^m / L_t \quad l_{i,t} = L_t^p / L_t \]

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

\[ \kappa_t = k_t / m_t \]

(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

\[ \pi_t = p_{2,t} / p_{1,t} = \frac{1 - \theta}{\theta} \left( \frac{X_{1,t}}{X_{2,t}} \right)^{1-\rho} = \frac{1 - \theta}{\theta} \left( \frac{a_0 k_t^\alpha m_t + bl_{1,t}}{bl_{2,t}} \right)^{1-\rho} \]

(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

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

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

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

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:

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

$$w_{2,t}^M = p_{2,t}b, \quad (11)$$

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

$$w_t^M = \max \{w_{1,t}^M, w_{2,t}^M\} \quad (12)$$

Similarly, female shadow wage is

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

which reflects mental labor productivity in the first sector.
2.3.2 Households

Household’s maximizing problem yields

\[
zn_t = \begin{cases} 
\gamma(1 + w_t^M/w_t^F) & \text{if } \gamma(1 + w_t^M/w_t^F) \leq 1 \\
2\gamma & \text{if } 2\gamma \geq 1 \\
1 & \text{otherwise.}
\end{cases}
\] (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 \( 2\gamma \) of their time raising children. Finally, under our assumption \( \gamma < 1/2 \) the budget constraint (11) collapses to

\[
s_t = (1 - zn_t)w_t^F + w_t^M
\] (15)

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

\[
zn_t = \min \{ \gamma(1 + \omega_t), 1 \}. \] (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

\[ 2 - \alpha \geq 1/\theta \]  

(17)
to be satisfied throughout the following analysis. Under this assumption, \( L^p_{1,t} > 0 \) holds and the ratio of male to female wage can be computed by the marginal productivities in the first sector

\[ \omega_t = 1 + \frac{b}{(1 - \alpha)ak_t^\alpha}. \]  

(18)

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

\[ zn_t = \min \left\{ \gamma \left( 2 + \frac{b}{(1 - \alpha)ak_t^\alpha} \right), 1 \right\}. \]  

(19)

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

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

(20)

Further note that

\[ l_{1,t} = m_t - (1 - zn_t) \]  

(21)

so that equation (20) becomes

\[ (1 - \alpha) \frac{a}{b}k_t^\alpha + 1 = \frac{1 - \theta}{\theta} \left( \frac{\kappa_t^\alpha m_t + m_t - (1 - zn_t)}{1 - m_t + (1 - zn_t)} \right)^{1 - \rho}. \]  

(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

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\(^{14}\)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 $\kappa_t$ (substitute $m_t = k_t/\kappa_t$):

\[
(1 - \alpha) \frac{a}{b} \kappa_t^\alpha + 1 = \frac{1 - \theta}{\theta} \left( \frac{\frac{a}{b} \kappa_t^{1-\alpha} + \frac{k_t}{\kappa_t}}{1 - \frac{2a}{b} \kappa_t} \right)^{1-\rho}.
\] (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

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

Equations (23) and (24) determine the equilibrium $\kappa_t$ in the first and second regime, respectively. Notice that expressions on the left of both equations are increasing in $\kappa_t$, while both terms on the right are decreasing in $\kappa_t$. This implies that $\kappa_t$ 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 $\gamma (2 + b/[(1 - \alpha)a\kappa_o^{\alpha}]) = 1$ with equation (23) and $\kappa_o = k_o/m_o$, this threshold is shown to be

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

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

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 $L_t + L^*_t$.

\[15\] 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).

\[16\] 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

\[ FPES_t = \{ (\lambda_t, k_t, k^*_t) \in FD_t \mid w^M = w^{*,M}, w^F = w^{*,F}, r = r^* \}. \]  

(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.\(^{18}\) 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. \( \blacksquare \)

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: \( zn_t = zn_t^* = \bar{z}n_t \).\(^{19}\) Combining these equations leads to:

\[ \bar{\kappa}_t = \frac{k_t}{l_{1,t} + 1 - \bar{n}_t} = \frac{k_t^*}{l_{1,t}^* + 1 - \bar{n}_t}. \]  

(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.

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\(^{17}\)Remember that the absence of superscript \(^A\) indicates equilibrium variables under free trade – e.g. at \( w^M \), \( w^{*,M} \) etc.

\(^{18}\)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.

\(^{19}\)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 $l_{1,t} < l^*_t$ and thus $l_{2,t} > l^*_t$. Consequently, the relevant resource constraints $l_{1,t}, l^*_t \leq 1$ lead to a restriction on capital stock conditions for factor price equalization to hold:

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

(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

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

(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:

$$m_t = \frac{k_t}{\tilde{k}_t} < \frac{k_t^*}{\tilde{k}_t} = m_t^*,$$

while

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

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:

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

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 $\kappa_t$ and thereby foster female labor force participation.
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 \( \kappa_t^* \), which increases the gender wage gap and decreases female labor force participation.

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 \( \pi_t \) – i.e., for the moment, we assume that Home is a small open economy. We determine how the equilibrium gender wage gap \( \omega_t \) 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 \( \underline{\pi}, \bar{\pi} \) with \( 0 < \underline{\pi} < \pi_t^4 < \bar{\pi} \) so that

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

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

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

20The 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

$$\omega_t = \frac{\pi_t}{\pi_t - 1}$$  \hspace{1cm} (31)$$
as long as \(l_{1,t}, l_{2,t} > 0\), implying that \(\omega_t\) is decreasing in \(\pi_t\). By (16) this means that \(zn_t\) is decreasing in \(\pi_t\), 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 \(\pi_t\) and hence, as \(m_t = l_{1,t} + 1 - zn_t\), must be decreasing in \(\pi_t\). Therefore, \(l_{1,t}(\pi_t)\) is decreasing in \(\pi_t\). The constraint \(l_{1,t} \in [0, 1]\) then implies that there are two prices \(\bar{\pi}\) and \(\underline{\pi}\) so that \(l_{1,t}(\bar{\pi}) = 1\) and \(l_{1,t}(\underline{\pi}) = 0\). Consider now prices \(\pi_t\) with \(\pi_t \leq \bar{\pi}\) and check that (12) gives

$$\omega_t = 1 + [(1 - \alpha) a/b \kappa_t^\alpha]^{-1}$$  \hspace{1cm} (32)$$
Thus, \(\omega_t\) is constant in \(\pi_t\) (check with (10) and (11) that \(l_{1,t} = 1\) throughout this range). For prices \(\pi_t\) satisfying \(\pi_t \geq \bar{\pi}\) (12) implies

$$\omega_t = \pi_t[(1 - \alpha) a/b \kappa_t^\alpha]^{-1}$$  \hspace{1cm} (33)$$
Thus, starting at \(\pi_t = \bar{\pi}\), increases in \(\pi_t\) cannot increase \(m_t = 1 - zn_t\) (16) would require a decrease in \(\omega_t\) contradicting equation (33) and must widen the gender wage gap \(\omega_t\). 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 \(\pi_t < \bar{\pi}\), \(l_{1,t} = 1\) and \(\omega_t\) constant. Hence, \(m_t = l_{1,t} + 1 - zn_t\) is constant and so is output of \(X_1\). In the range \(\pi_t \in (\bar{\pi}, \bar{\pi})\) the gender wage gap \(\omega_t\) is decreasing and hence \(\kappa_t\) increases, as (18) holds. Thus, \(X_1\) from (2) decreases. Finally, for \(\pi_t > \bar{\pi}\) the employment \(m_t = 1 - zn_t\) in \(X_1\)-sector decreases (\(\omega_t\) increases while \(l_{1,t} = 0\) holds). Thus, \(X_1\) output falls. ■

Figure 2 summarizes part (i) of the Lemma. For small \(\pi_t\), 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 \( \pi_t \in (\bar{\pi}, \bar{\bar{\pi}}) \),
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
\( \omega_t \) 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 \( \omega_t \)
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 \( \pi_t \) is not too large, then the effect of trade is a reduction in the gender wage gap
\( \omega_t \) and thus a decrease in fertility \( n_t \) plus an increase in female labor force participation
\( (1 - zn_t) \). Second, if \( \pi_t \) is sufficiently large, then trade induces an increase in \( \omega_t \) and \( n_t \) and
a decrease in \( (1 - zn_t) \). In Figure 2 the threshold that separates the two cases is labeled
\( \pi_u \). 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 \( \pi_t^A \), 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 \( \pi_t \) lies between the respective autarky prices:

\[ \pi_t^A \leq \pi_t \leq \pi_t^{*,A}. \]  

\(^{21}\) Notice that this threshold \( \pi_u \) depends on the capital stock of the economy and could be written as
\( \pi_u(k_t) \).
Thus, trade (weakly) increases relative prices $\pi_t$ 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 $\omega_t$ 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 $\omega_t$ and an increase in female labor force participation if and only if $\pi_t$ is not too high (i.e., $\pi_t \leq \pi_u$ holds). 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)

$$
(1 - \alpha) \frac{a}{b} (\kappa_t^*)^{\alpha} + 1 \geq \pi_t \geq (1 - \alpha) \frac{a}{b} \kappa_t^{\alpha} + 1
$$

holds. Proposition 1, however, states that factor price equalization requires $\kappa_t = \kappa_t^*$, implying $\pi_t = (1 - \alpha) \frac{a}{b} \kappa_t^{\alpha} + 1$. By construction of $\pi$, however, all world equilibria with $\pi_t \in (\overline{\pi}, \pi_u)$ are characterized by equality $\pi_t > (1 - \alpha) \frac{a}{b} \kappa_t^{\alpha} + 1$, implying that factor prices do not equalize. Since finally, by construction of $\pi_u$ we have $\omega_t > \omega_t^A$ 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**

22 Notice that, by assumption (17) $\pi_t^{*,A} < \pi_u$ holds for Foreign. However, the threshold $\pi_u(k_t^*)$ depends on Foreign’s capital and one cannot conclude that $\pi_t \leq \pi_t^{*,A} < \pi_u(k_t)$ 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 $S_t \subset F_D_t$ with $FPES_t \subseteq S_t$ 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.

3 Empirical Evidence

Our theory predicts that, when trading with a poor economy, trade decreases aggregate female labor force participation and female relative wage in the rich economy. We choose to test the predictions through the surge in U.S.-Mexican trade during the period 1990–2007, a period of trade liberalization, which we simply label the “NAFTA episode” in the following.

A brief explanation of our empirical strategy seems appropriate. One may argue that focusing on aggregate female labor is not the most direct way to test our theory but rather examining the reallocations of male and female labor across sectors. However, two crucial reasons dictate our choice. First, the empirical trade literature found that industry-level data hide substantial intra-industry product heterogeneity (Schott 2003). Moreover, Schott

\footnote{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.}
(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. Second, and as we explain in the introduction, aggregate female labor drops in response to trade liberalization, while female employment in the female intensive sector may stay constant or actually increase.

The choice of the NAFTA episode has a number of virtues. First, the U.S. and Mexico are paradigmatic for a pair of capital-rich and capital-poor economies, for which our theory applies. As a second advantage of the NAFTA episode, U.S.-Mexican trade experienced a substantial growth during that period: U.S. trade with Mexico as a share of U.S. GDP increased more than three-fold between 1990 and 2007, while Mexico’s share in U.S. total trade rose by a factor of more than two (Figure 3). Via this substantial increase of bilateral trade volumes, we 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. In particular, we can exploit exposure to trade with Mexico on a U.S. state level. Finally, due to the specific geographical constellation, U.S. trade with Mexico is particularly uneven across U.S. states, which allows us to use distance as a powerful instrument for a change in trade volumes and thus establish causality running from change in trade to change in female labor share and female relative wage.

In deciding whether to emphasize wages or employment in our empirical analysis, we notice that the empirical trade literature has documented an asymmetric impact of glob-

\[ \text{Capital stocks per worker can be calculated from real investment data as in PWT6.2. At depreciation} \\
\text{rates of between .01 and .1, the relative capital stock of the U.S. in 2003 exceeded that of Mexico by a factor} \\
\text{of four. Consistent with our theory, the female labor share in the U.S. ranged from 43.1 to 46.3 between} \\
\text{1985 and 2006, while the according range for Mexico is 29.4 to 35.3 (United Nations Statistics Division).} \]
eralization 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 blurs the impact of trade on wages as workers with specific characteristics systematically exit the labor market. Therefore, our empirical part 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.

3.1 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). From IPUMS-CPS we take the variables age, sex, marital status, population status (to distinguish between civilian or Armed Forces), nativity (to identify immigrants), location (state), Hispanic origin (to identify Mexicans), 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). Table 1 provides descriptive statistics for female and male labor for the years 1990/91 and 2006/07. Two observations can be drawn from Table 1 during the NAFTA episode: first, while female labor force participation has increased, male labor force participation has decreased and, second, the hourly wage for both genders has increased during the same period. The second database we use is the ‘Origin of Movement’ administered by WISER, 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.

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.\footnote{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.}

As discussed in the introduction, previous empirical literature has revealed that the impact of trade liberalization on wages is smaller than the impact on employment and that the latter is of marginal magnitude. Thus, we begin by examining whether NAFTA had any impact on female employment at all, and subsequently move our attention to its impact on wages.

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 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:

$$\Delta y_s = \alpha + \beta \Delta Trade_s + X'_s \gamma + u_s$$  \hspace{1cm} (36)

where for any variable, $z_s$ the $s$ indicates the different U.S. states and $\Delta$ indicates the change over time - before and after NAFTA. The dependent variable $y_s$ is the female labor share, $Trade_s$ 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. Our theory predicts that the estimate of $\beta$ in (36) is negative.

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 endogeneity 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 $\Delta \text{Trade}_s$ by distance to Mexico. Thus, our first stage regression is:

$$\Delta \text{Trade}_s = \mu + \theta d_s + X'_s \rho + \nu_s$$  \hspace{1cm} (37)

where $d_s$ is distance of state $s$ to Mexico.

Figure 4 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 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 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

\footnote{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.}

\footnote{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.}
likely to hold. 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.

3.2.2 Control Variables

To control for differential business cycle effects across states, we include the change in log per capita “Gross State Product” (GSP) and unemployment rate. We also control for the change in average education level for females, which is positively correlated with female labor share. Further, we include the share of Mexican immigrants, which might either depress female labor participation – e.g. if cultural differences reduce gender labor market participation – or else increase female labor participation – e.g. by increasing supply of nannies and private child-care. We have no strong prior on the sign of this latter control variable.

31 Exact details about our falsification test are explained in the First Appendix and its results are reported in Table 7.
32 We define two categories of education. First, educated individuals who have at least some college-training and for whom we assign a weight of 1. Second, uneducated individuals who are at most high school graduates and for whom we assign a weight of 0. The education level of a state is defined as the average of individual weights.
33 On a national level, this concern seems unsubstantiated: national averages of female hours worked as percentage of male hours worked of Mexicans exceed the according numbers of the full sample by 0.5% to 1.9% between 1990 and 2007.
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). In choosing our instrument for the initial levels of female labor force participation we thus assume that the levels in 1980/81 affect the changes in female labor force participation during the period 1990/91–2006/7 only through the levels of 1990/91.

3.2.3 Regression Results

For our baseline specification, we define female labor participation as the share of hours worked by females. Taking this share is not a strict necessity, but it eliminates labor market shocks that are common to both sexes. 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. 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 labor share on an initial level of female labor share, which we take to be the average of 1980 and 1981 and the change in trade with Mexico. As discussed earlier, we are not surprised by insignificant coefficient of our main variable, ∆Trade with Mexico, since this OLS regression suffers from a bias due to endogeneity problems. E.g. higher female labor force participation strengthens the comparative advantage in the capital-intensive sector, which generates higher international trade on female labor share.

\[34\] We assume that import equalizes export in order to reveal, quantitatively, a more realistic coefficient of trade on female labor share.
specialization and trade.

To avoid this endogeneity and to identify the causal relation running from change in trade to female labor shares, we focus on the remaining five columns that summarize IV estimates, where the change in trade is instrumented by distance. Column 2 reports estimates without controls, Column 3 includes average female labor share of 1990 and 1991, which is instrumented by the average values of 1980 and 1981; Column 4 includes the differences of log per capita GSP and unemployment share; Column 5 includes differences in female education share and Column 6 includes change in Mexican immigration share.

The coefficient of interest is the one on change in trade with Mexico ($\beta$). All of its estimates have the expected negative sign and most of them are significant on the one percent confidence level. Column 3 indicates that a one percent increase in trade share with Mexico (as experienced by Arizona) decreases the female relative to male labor share by around 1.5 percent. The coefficient on the initial level of female labor share is negative and significant, as generally implied by convergence.

### 3.2.4 Robustness

We next conduct some robustness checks for the results obtained in the baseline regression (Column 3 in Table 2). First, we exclude Texas as well as Alaska and Hawaii from the sample since these states appear to be outliers in terms of distance (see Figure 4), and hence in predicted trade shares. Table 3 summarizes the corresponding results in the first three columns. The exclusions do not affect 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 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 3 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). 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 3). Results show that neither the point estimates nor the significance level are affected.

Since our theory rests on intra household optimization, it seems appropriate to restrict our sample to married individuals only. Column 6 in Table 3 shows that the point estimates remain in the same range and only the significance level drops slightly to 5%.

Next, we replace the definition of our dependent variable from share of hours to relative employment. This obviously eliminates the important intensive margin of individuals’ labor market participation. Nevertheless, Column 7 in Table 3 shows that the estimates are significant at the 5% level.

Our theory suggests that trade-induced specialization reduces female labor force participation in capital-rich country while making male workers merely change sectors. Consequently, we need to check that our results above are driven by changes in female employment only. We do so by investigating the impact of trade on female and male working hours separately. 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 according numbers for male are 32.92 (1.89) and 32.2 (1.81), respectively (Table 1). These regressions are summarized in Table 4. While all point estimates of the coefficient on change in trade share with Mexico are negative and significant for females, trade, overall, does not significantly impact male labor hours: estimates are mostly insignificant, positive and around zero.

Finally, we limit our sample to highly educated individuals for several reasons. First, our theory suggests that female labor force participation drops due to the decrease in the relative price of mental labor, which may be associated with higher education. Second,

\[35\text{Ground distance is measured in time and derived from maps.google.com.}\]

\[36\text{Columns 2, 4, 6 and 8 in Table 4 show that using population weight to unravel the impact of change in trade at the individual level does not change neither the magnitudes of our estimates nor their significance.}\]
this limitation eliminates the possibility that our estimated effects stem from alternative mechanisms.\textsuperscript{37} Consistent with our theory, Table 5 shows that all regressions exhibit a negative impact of trade on female labor force participation, while such an impact does not prevail for male workers.

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 females’ 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. females. 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. females 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 equal, a state that is subject to higher expansion in trade with Mexico will experience a larger decreases in female relative wage.

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

\[
\Delta \left( \frac{w_f}{w_m} \right)_s = \alpha' + \beta' \Delta Trade_s + X'_s \gamma' + v_s
\]

(38)

The dependent variable \( \Delta \left( \frac{w_f}{w_m} \right)_s \) is the change in the relative wage of females in state \( s \). We keep the same notation of section 3.2. Our theory predicts that the estimate of \( \beta' \) in (38) is negative.

\textsuperscript{37}Thus, one may conjecture that the estimates pick up a negative correlation between the share of unskilled women and distance from Mexico. In this case, in states neighboring Mexico, a larger share of women would be affected by adverse wage shocks due to trade, resulting in a larger drop in female labor force participation.
We focus on one specification, which corresponds to the one in Column 3 of Table 2. Accordingly, 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 on an initial level of female relative wage, which we take to be the average of 1980 and 1981 and the change in trade with Mexico. 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 $\beta'$ 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 females and $43\%$ – $64\%$ for males. We then estimating 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 90th and 85th 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.
distribution. This latter observation is consistent with the view that the females who are endowed with relatively high mental labor endowments are those whose wages are negatively affected by trade.

4 Concluding Remarks

This paper analyzes how expansions and contractions of sectors that use female labor intensively affect aggregate female labor force participation. We argue that when international trade expands sectors conductive to female employment, female labor force participation drops, and vice versa. This is because male workers earn higher wages than women and are therefore always formally employed. Thus, when an economy specializes in sectors intensively use female labor, other sectors contract and male workers move to the expanding sectors, driving female workers out of formal employment.

Finally, 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. Instrumenting trade shares with geographic distance, our cross-state regressions support the hypothesis that, in rich economies, international trade with poor countries tends to reduce female labor supply. These findings are robust to various definitions of female labor supply and a set of controls.
References


Figures & Tables

Figure 1: Factor Price Equalization Set

Figure 2: Gender Wage Gap and World Price

38
Figure 3: 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.

Figure 4: Change in Trade with Mexico by State (1990-2007). left Panel: all states; right panel: excluding Alaska, Hawaii and Texas.

slope = -2.13  t-statistic= -3.92

slope = -3  t-statistic= -3.75
Table 1: Characteristics of U.S. Data, 1990/91 and 2006/07

<table>
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<th>1990/91</th>
<th>2006/07</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (%)</td>
<td>39.38</td>
<td>56.55</td>
</tr>
<tr>
<td></td>
<td>(5.59)</td>
<td>(5.36)</td>
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<tr>
<td>Weekly hours worked</td>
<td>22.77</td>
<td>24.24</td>
</tr>
<tr>
<td></td>
<td>(1.92)</td>
<td>(1.84)</td>
</tr>
<tr>
<td>Hourly wage</td>
<td>11.39</td>
<td>14.55</td>
</tr>
<tr>
<td></td>
<td>(1.65)</td>
<td>(2.22)</td>
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<tr>
<td>Employment (%)</td>
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<td>67</td>
</tr>
<tr>
<td></td>
<td>(5.2)</td>
<td>(4.7)</td>
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<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (%)</td>
<td>41.21</td>
<td>50.87</td>
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<tr>
<td></td>
<td>(6.36)</td>
<td>(5.92)</td>
</tr>
<tr>
<td>Weekly hours worked</td>
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<td>32.2</td>
</tr>
<tr>
<td></td>
<td>(1.89)</td>
<td>(1.81)</td>
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<tr>
<td>Hourly wage</td>
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<td>19.14</td>
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<tr>
<td></td>
<td>(2.02)</td>
<td>(3.24)</td>
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<td>Employment (%)</td>
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<td>77</td>
</tr>
<tr>
<td></td>
<td>(3.6)</td>
<td>(4.2)</td>
</tr>
<tr>
<td><strong>State</strong></td>
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<td></td>
</tr>
<tr>
<td>per-capita GSP</td>
<td>28321</td>
<td>37968</td>
</tr>
<tr>
<td></td>
<td>(11307)</td>
<td>(13881)</td>
</tr>
<tr>
<td>Trade share (%)</td>
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<td>1.21</td>
</tr>
<tr>
<td></td>
<td>(0.98)</td>
<td>(1.51)</td>
</tr>
<tr>
<td>Unemployment (%)</td>
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<td>4.82</td>
</tr>
<tr>
<td></td>
<td>(1.36)</td>
<td>(1.09)</td>
</tr>
<tr>
<td>Mexican Immigrants (%)</td>
<td>1.47</td>
<td>2.94</td>
</tr>
<tr>
<td></td>
<td>(3.03)</td>
<td>(3.69)</td>
</tr>
</tbody>
</table>

**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. Employment is the share of the working group 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.
Table 2: The Effect of U.S. Trade with Mexico on U.S. Female Labor Force Participation during the period 1990/91–2006/07

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Trade</td>
<td>-0.280</td>
<td>-0.806*</td>
<td>-1.506***</td>
<td>-1.879***</td>
<td>-1.268***</td>
<td>-1.259***</td>
</tr>
<tr>
<td></td>
<td>(0.201)</td>
<td>(0.409)</td>
<td>(0.420)</td>
<td>(0.689)</td>
<td>(0.424)</td>
<td>(0.445)</td>
</tr>
<tr>
<td>FLFP 80/81</td>
<td>-0.248***</td>
<td>0.157</td>
<td>-0.760***</td>
<td>-0.629***</td>
<td>-0.601***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td>(0.157)</td>
<td>(0.179)</td>
<td>(0.129)</td>
<td>(0.152)</td>
<td></td>
</tr>
<tr>
<td>Δ ln(GSP)</td>
<td></td>
<td></td>
<td>0.020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.016)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Unemp</td>
<td></td>
<td></td>
<td>0.490**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.213)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Fem Edu</td>
<td>0.125**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.051)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Mex imm</td>
<td>-14.010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(12.342)</td>
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<td></td>
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</table>

First-Stage Coefficients

<table>
<thead>
<tr>
<th></th>
<th>(Dependent Variable: Δ Trade)</th>
<th>(Dependent Variable: FLFP in 1990/91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>-2.134***</td>
<td>-0.223</td>
</tr>
<tr>
<td></td>
<td>(0.544)</td>
<td>(0.972)</td>
</tr>
<tr>
<td>FLFP 80/81</td>
<td>-2.021***</td>
<td>-0.611</td>
</tr>
<tr>
<td></td>
<td>(0.581)</td>
<td>(1.061)</td>
</tr>
<tr>
<td>Joint F-test</td>
<td>15.39</td>
<td>35.01</td>
</tr>
<tr>
<td></td>
<td>12.66</td>
<td>35.56</td>
</tr>
<tr>
<td></td>
<td>12.63</td>
<td>37.47</td>
</tr>
<tr>
<td></td>
<td>12.08</td>
<td>34.32</td>
</tr>
</tbody>
</table>

| Obs               | 51                            | 51                                   |
| Method            | (OLS) (IV) (IV) (IV) (IV) (IV) |

Note.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. All models are weighted by CPS sampling weights. In the bottom part of the table we show the first stage coefficients for the corresponding specifications. We report only the coefficients of the two instruments and the F-test for the joint significance of the instruments. See the note to Table 1 for additional sample details and variables definition.
Table 3: The Effect of U.S. Trade with Mexico on U.S. Female Labor Force Participation

<table>
<thead>
<tr>
<th>Dependent Variable: Change in Females Share in Average Hours Worked</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trade with Mexico</strong></td>
<td><strong>FLFP in 1990/91</strong></td>
</tr>
<tr>
<td>TX</td>
<td>Excluding</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>(\Delta) Trade with Mexico</td>
<td>(-1.917^{***})</td>
</tr>
<tr>
<td>FLFP in 1990/91</td>
<td>(-0.684^{***})</td>
</tr>
</tbody>
</table>

First-Stage Coefficients (Dependent Variable: \(\Delta\) Trade)

<table>
<thead>
<tr>
<th>Distance</th>
<th>(Dependent Variable: FLFP in 1990/91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>Excluding</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Distance</td>
<td>(-1.409^{**})</td>
</tr>
</tbody>
</table>

First-Stage Coefficients (Dependent Variable: FLFP in 1990/91)

<table>
<thead>
<tr>
<th>FLFP in 1980/81</th>
<th>(Dependent Variable: FLFP in 1990/91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>Excluding</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>FLFP in 1980/81</td>
<td>(0.532^{***})</td>
</tr>
</tbody>
</table>

Number of obs

50 49 48 51 51 51 51

Note.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. All the above regressions are conducted according to the model described in Column 3 in Table 2. For each one of the first stage regressions we report only the relevant instrument. See the note to Table 1 for additional sample details and variables definition.
### Table 4: The Effect of U.S. Trade with Mexico on U.S. Females/Males Labor Force Participation

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hours worked</th>
<th>Employment</th>
<th>Hours worked</th>
<th>Employment</th>
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<tbody>
<tr>
<td></td>
<td>FEMALE</td>
<td>MALE</td>
<td>FEMALE</td>
<td>MALE</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>State Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Trade with Mexico</td>
<td>$-0.72^{**}$</td>
<td>$-0.65^{***}$</td>
<td>$-0.02^{**}$</td>
<td>$-0.02^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.27)</td>
<td>(0.17)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>LFP in 1990/91</td>
<td>$-0.25^{**}$</td>
<td>$-0.42^{***}$</td>
<td>$-0.29^{***}$</td>
<td>$-0.39^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.07)</td>
<td>(0.08)</td>
<td>(0.08)</td>
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</table>

<table>
<thead>
<tr>
<th>First-Stage Coefficients</th>
<th>(Dependent Variable: Δ Trade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$-2.06^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
</tr>
<tr>
<td></td>
<td>$-2.06^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.57)</td>
</tr>
<tr>
<td></td>
<td>$-2.12^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
</tr>
<tr>
<td></td>
<td>$-2.10^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
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</table>

<table>
<thead>
<tr>
<th>First-Stage Coefficients</th>
<th>(Dependent Variable: LFP in 1990/91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFP in 1980/81</td>
<td>0.93^{***}</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
</tr>
<tr>
<td></td>
<td>0.92^{**}</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
</tr>
<tr>
<td></td>
<td>0.67^{***}</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
</tr>
<tr>
<td></td>
<td>0.74^{***}</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
</tr>
</tbody>
</table>

| Number of obs | 51 | 51 | 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 3 in Table 2. The independent variables are instrumented by distance and the according Labor Force Participation shares in 1980/81. For each one of the first stage regressions we report only the relevant instrument. Regressions described in Columns 2, 4, 6 and 8 are weighted by state population size. See the note to Table 2 for additional sample details and variables definition.
| Dependent Variable | FEMALE | | | | | | MALE | | | | | | |
|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| State Weight       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|                    | (1)    | (2)    | (3)    | (4)    | (5)    | (6)    | (7)    | (8)    |        |        |        |        |        |        |
| ∆ Trade with Mexico|        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|                    | (0.25) | (0.15) | (0.01) | (0.00) | (0.38) | (0.15) | (0.01) | (0.00) |        |        |        |        |        |        |
| LFP in 1990/91     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|                    | (0.1)  | (0.08) | (0.08) | (0.11) | (0.09) | (0.1)  | (0.21) | (0.19) |        |        |        |        |        |        |
| Number of obs      | 51     | 51     | 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 3 in Table 2. The independent variables are instrumented by distance and the according Labor Force Participation shares in 1980/81. For each one of the first stage regressions we report only the relevant instrument. We define skilled individuals by those who are at least high school graduates. Regressions described in Columns 2, 4, 6 and 8 are weighted by state population size. See the note to Table 1 for additional sample details and variables definition.
Table 6: The Effect of U.S. Trade with Mexico on U.S. Females' Relative Hourly Wage: \((w_f/w_m)\)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Female wage over male based on:</th>
<th>(90^{th})</th>
<th>(85^{th})</th>
<th>(80^{th})</th>
<th>(70^{th})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta) Trade with Mexico</td>
<td>Average Wage</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>(w_f/w_m) in 1990/91</td>
<td>(0.563)</td>
<td>(-0.179)</td>
<td>(-0.687^{**})</td>
<td>(-0.674^{***})</td>
<td>(-0.469^{**})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First-Stage Coefficients</th>
<th>(Dependent Variable: (\Delta) Trade)</th>
<th>(90^{th})</th>
<th>(85^{th})</th>
<th>(80^{th})</th>
<th>(70^{th})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>(-3.011^{***})</td>
<td>(-2.958^{***})</td>
<td>(-2.878^{***})</td>
<td>(-2.885^{***})</td>
<td>(-2.91^{***})</td>
</tr>
<tr>
<td>(0.803)</td>
<td>(0.825)</td>
<td>(0.836)</td>
<td>(0.825)</td>
<td>(0.807)</td>
<td></td>
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<table>
<thead>
<tr>
<th>First-Stage Coefficients</th>
<th>(Dependent Variable: (w_f/w_m) in 1990/91)</th>
<th>(90^{th})</th>
<th>(85^{th})</th>
<th>(80^{th})</th>
<th>(70^{th})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(w_f/w_m) in 1980/81</td>
<td>(0.683^{***})</td>
<td>(0.417^{***})</td>
<td>(0.659^{***})</td>
<td>(0.685^{***})</td>
<td>(0.654^{***})</td>
</tr>
<tr>
<td>(0.132)</td>
<td>(0.104)</td>
<td>(0.119)</td>
<td>(0.112)</td>
<td>(0.87)</td>
<td></td>
</tr>
</tbody>
</table>

| Number of obs | 51 | 51 | 51 | 51 | 51 |

Note.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. All regressions correspond to the model described in Column 3 in Table 2 in the case of labor supply. The independent variables are instrumented by distance and the according relative females wage 1980/81. For each one of the first stage regressions we report only the relevant instrument. See the note to Table 1 for additional sample details and variables definition.
First Appendix

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 3). 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 7 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 7: Explanatory Power of Distance on Female Labor Force Participation

<table>
<thead>
<tr>
<th>Dependent Variable: Change in</th>
<th>Share of Hours Worked</th>
<th>Relative Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre NAFTA</td>
<td>NAFTA</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>distance</td>
<td>−3.933*** (1.44)</td>
<td>2.703*** (0.562)</td>
</tr>
<tr>
<td>Initial FLFP</td>
<td>−0.009 (0.111)</td>
<td>−0.544*** (0.08)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>First-Stage Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Dependent Variable: Initial level for FLFP)</td>
</tr>
<tr>
<td>Lagged FLFP</td>
<td>0.675*** (0.085)</td>
</tr>
</tbody>
</table>

**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 females 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 1 for additional sample details and variables definition.
Second Appendix

Proofs

Proof that $1/m_t$ is bounded above. First observe that $k_t \to \infty$ means $k_t > k_o$ so that the second regime applies. Use (24) to confirm that $\kappa_t \to \infty$ as $k_t \to \infty$ (else the denominator in the brackets of the expression on the right turns negative). Finally, divide equation (22) by $\kappa_t^\alpha$ to get

$$
\frac{1}{\theta} \frac{1}{\kappa_t^\alpha} \left( \frac{\frac{a}{2}m_t + [m_t - (1 - zn_t)] \kappa_t^{-\alpha}}{1 - m_t + (1 - zn_t)} \right)^{1-\rho} \to (1 - \alpha) \frac{a}{b} \quad (k_t \to \infty).
$$

Since this limit is positive, the term in brackets must approach infinity as $k_t \to \infty$ so that, as $\lim_{k_t \to \infty} zn_t = 2\gamma$, $\lim_{k_t \to \infty} m_t = 2(1 - \gamma)$ must hold. This proves that $1/m_t$ is bounded above. 

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 $r_t = p_{1,t} \alpha a \kappa_t^{\alpha-1} = p_{1,t} \alpha a (\kappa_t^*)^{\alpha-1} = r_t^*$ and $w_t^F = p_{1,t}(1 - \alpha)a\kappa_t^\alpha = p_{1,t}(1 - \alpha)a(\kappa_t^*)^\alpha = w_t^{F,*}$. 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. 

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