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Abstract

Male and female labor are imperfect substitutes and some sectors are more suitable for female employment than others. Clearly, expansions of those sectors that use female labor intensively must affect aggregate female labor force participation (FLFP). We suggest that FLFP actually *drops* when trade and international specialization *expand* sectors that use female labor intensively. This effect arises because expansions of the former sectors come along with contractions of others. The latter contractions, in turn, induce male workers to move to the expanding sectors, driving female workers out of formal employment. Thus, a country that is exporting female labor content is actually substituting male labor for female. Finally, building on U.S.-Mexican trade data, we provide empirical evidence that support our argument.

Keywords: Trade, Female Labor Force Participation, Fertility, Technological Change.

JEL Classifications: F10, F16, J13, J16.

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1 Introduction

World trade volumes have increased secularly during the last century. From 1870 to 1998 growth in world trade has quadrupled growth in world income (Maddison (2001)). Another significant feature of the twentieth century was the increase in female labor force participation. The participation of married women in the U.S. labor market has been increasing from around 2% in 1880 to over 70% in 2000 (Fernández (2007)).

The focus of this study is to understand channels through which two major economic factors, international trade and female labor force participation, are linked. Our main concern is to show how differences in capital labor ratios across economies, via international specialization, affect the trade-off in household decisions between fertility and female labor force participation and how these decisions, in turn, feed back on growth rates of per household capital stocks.

Our theory relies on an assumption concerning labor supply that is consistent with empirical regularities: male workers have relative advantage in brawn intensive tasks and female workers have relative advantage in brain intensive tasks. More precisely, we assume that females and males have equal quantities of brains, but males have more brawn. As a direct consequence, males' wages are higher than females' wages as long as brawn is a valued input.[1] Indeed, Figure 1 shows that the wage ratio between female workers and male workers in the U.S. is less than one during the period 1800-1990.

Assumptions two and three characterize the labor demand of our model. Thus, childrearing is assumed to require time that cannot be spent working so that the opportunity cost of raising children is proportional to the market wage.[2] Therefore, given that males and females are equally productive in raising children, women with the lower market wage raise children.

[1] O'Neill (2003) shows that there is still a 10 differential in female and male wages in the U.S. in 2000, that is still unexplained by gender differences in schooling, actual experience and job characteristics.

[2] Goldin (1995) provides evidence that shows that few women in the 1940's and 1950's 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.

According to our third assumption physical capital complements brains more than brawn. In combination with the difference in endowments of brains and brawn between male and female workers, the last assumption implies that male labor and female labor are imperfect substitutes.[3] Moreover, as economies accumulate physical capital, the rewards to brains increase relative to brawn and the gender wage gap declines. Indeed, Goldin (1990) writes:

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

To formalize our three assumptions, we adopt the model of Galor and Weil (1996) and generalize it to a trade setting. Based on the intrinsic differences in labor endowments between the sexes we distinguish between a brain intensive sector, which we label "females' relative advantage sector" (FRAS) and a brawn intensive sector, or "males' relative advantage sector"(MRAS).

Within this framework, we analyze how female labor force participation is affected by an expansion or a contraction in a sector that intensively uses female labor. As a result of international trade, some economies specialize in FRAS, which expands on the expense of MRAS, while the opposite pattern displays in other economies. Interestingly, our theory suggests that expanding FRAS hinders female labor force participation, while expanding MRAS generates the mirror image.

The intuition of this seemingly paradoxical result runs along the following lines. First, men have higher wages and, therefore, are always formally employed. Second, when an economy specializes on the FRAS, the MRAS contracts and male workers move to the FRAS sector. Third, the inflow of male workers to the FRAS, depresses the capital-labor ratio in this sector. Thus, given the relatively strong complementarity between physical capital and

[3] Acemoglu, Autor and Lyle (2004) have utilized the large positive shock to demand for female labor induced by World War II to understand the effect of an increase in female labor supply on 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%. This suggests that the elasticity of substitution between female and male labor ranges between 2.5 and 3.5.

brains, the marginal productivity of brains drops by more than the marginal productivity of brawn, consequently increasing the wage gap. Finally, the increase in the wage gap depresses female labor force participation.

Simplifying this mechanism, it can be said that, by moving from MRAS to FRAS, male workers "drive female workers out" of formal employment. Conversely, under specialization on the MRAS, male workers withdraw from FRAS, which "opens job opportunities" for women and fosters female labor force participation.

Our mechanism also applies in the case of technological progress, which is biased towards female labor. In particular, technological progress biased towards FRAS increases the wages in this sector. This increase in wages attracts male workers who leave the MRAS, an effect that can be strong enough to drive female workers out of formal employment. In this way, technological progress biased towards female labor might curb female labor force participation.[4]

The dynamics of our two-country model are affected by three basic elements from trade and demographic theory. First, in a Heckscher-Ohlin framework, the relative endowments of production factors, physical capital, and labor, determine specialization patterns. Second, specialization patterns affect the gender wage gap. Third, the gender wage gap affects household choice of female labor force participation and fertility. These choices, in turn, impact household savings and population growth, which, finally, determine the per-household capital stock for the subsequent generation. Adding the complementarity assumption between physical capital and female labor described above, it is the capital abundant economy which specializes in the FRAS and vice versa.

Thus, our model suggests that international trade enhances growth of per-household capital in the capital scarce economy by fostering its female labor share and decreasing its fertility rates at the same time. The impact of trade on the capital abundant economy,

[4]For the role of technological progress in explaining the demographic transition see Galor and Weil ((1999), (2000)) and Galor and Moav (2002). For the impact of technological progress on fertility and female labor force participation see Greenwood and Seshadri (2005) and Doepke, Hazan and Maoz (2007).

however, is ambiguous. While international trade hinders female labor force participation and increases fertility, these adverse effects on per-household capital accumulation may or may not be dominated by the positive effects through the gains from trade. In either case, our model suggests that trade cannot accelerate capital accumulation in the rich country by more than it accelerates it in the poor country and, thus, our theory predicts convergence of per-household capital stocks.

The model connects to various strands in the literature. The work connecting international trade and labor markets typically analyzes the impact of trade on unemployment and labor reallocation (e.g., Davis (1998), Wacziarg and Wallack (2004) and Helpman and Itskhoki (2007)). Related articles reveal labor market friction as a determinant of comparative advantage and international trade (Saint-Paul (1997), Cunat and Melitz (2007)). Other scholars investigate whether to include labor market standards in trade agreements (Brown (2001) and Bagwell and Staiger (2001)). The link between trade, the gender wage gap and female labor force participation, however, is understudied. A noteworthy exception is Becker (1957) who argues that trade increases competition among firms and, thus, reduces costly discrimination and closes the gender wage gap. Tests of this hypothesis have generally produced mixed support (see Black and Brainerd (2004), Hazarika and Otero (2004), Berik, van der Meulen and Zveglich (2004) for some of the scarce empirical investigations). Our mechanism, in contrast, operates through the differential demand for gender labor across sectors and international specialization under perfectly competitive goods and factor markets.

A different literature addresses the reduction in the gender wage gap and the increase in women's labor force participation has been the subject of much debate. Welch (2000), Gosling (2003) and Black and Spitz-Oener (2007) focus on the role of primary attributes. While Welch (2000) and Gosling (2003) attribute the reduction in the gender wage gap to the expansion in the value of brains relative to brawn, Black and Spitz-Oener (2007) addresses the importance of the relative increases in non-routine analytic tasks and non-routine interactive tasks, which are associated with higher skill levels.[5] Our paper is close to this literature by taking primary attributes as the source of the gender wage gap.

The link between women's relative wages and fertility is fairly well established.[6]. In our framework, the pure effect of an increase in household income, holding the price of children constant, is to raise the demand for children. If all child-rearing are done by females, an increase in females' wages raises both household income and the price of children, and thus has offsetting income and substitution effects on the demand for children.[7] In our model, if both males' and females' wages proportionately increase, then the substitution effect driven by the increase in the cost of raising children negates the income effect and leaves fertility unchanged. In such a framework, closing gender wage gap causes fertility to decline.[8]

There is little research on the links and interactions between demography and international trade. Closest to our argument is Galor and Mountford (2008) who endogenize 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.[9] Our theory predicts the opposite effect: trade reduces fertility in developing countries and enhances capital accumulation and growth of income per-capita, simultaneously highlighting its impact on female labor force participation.

To advance our understanding of how trade affects female labor force participation quantitatively, we test our theory using bilateral trade data for the U.S. (the rich economy) and

[5]See also Mulligan and Rubinstein (2005) who attribute the reduction in the gender wage gap to a positive selectivity bias and Fernández (2007) who addresses the role of culture and learning. For gender wage gap in the U.S., see Goldin (1990) and for the evolution of female labor force participation, see Goldin (2006).

[6]The analysis of fertility in the context of relative wages dates back to Becker (1960) and Mincer (1963)

[7]Pencavel (1986) finds a positive association between fathers' labor supply and the number of children. This is consistent with our framework assuming that fathers' wage has a pure income effect on the number of children.

[8]For a comprehensive discussion on the demographic transition see Galor (2005).

[9]Their theory suggests that international trade enhanced the specialization of industrial economies in the production of skill intensive goods. The increase in demand for skilled labor induced an investment in the quality of the population, expediting demographic transition, stimulating technological progress and further enhancing the comparative advantage of these industrial economies in the production of skill intensive goods. Thus, the pattern of trade enhances the initial pattern of comparative advantages and disadvantages.

Mexico (the poor economy). Central to our estimation strategy is the observation that the surge in bilateral trade volumes over the period 1990-2007 was uneven across the 51 U.S. states. 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. 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.

The rest of the paper is organized as follows. Section 2 formalizes our argument, section 3 provides an empirical evidence and section 4 presents some concluding remarks. Figures and tables appear at the end.

2 The Model

In our modeling strategy we follow Galor and Weil (1996) by adopting a standard OLG model with endogenous choice of 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:

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

Intermediate goods are produced using three factors: capital K, physical labor L^p, and mental labor L^m. We want to reflect the fact that sectors vary in their factor intensity, in particular, in their intensity of mental and physical labor. This, in turn, generates differences in demand for male and female labor across sectors. Thus, we impose the following structure on production of intermediate goods[10]

$$\begin{aligned} X_1 &= a K_t^{\alpha} (L_t^m)^{1-\alpha} + b L_{1,t}^p \\ X_2 &= b L_{2,t}^p. \end{aligned} \tag{2}$$

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

2.1.2 Labor Supply

Men and women are equally efficient in raising children. On the labor market, however, each woman supplies one unit of mental labor L^m while men supply 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 male workers cannot divide mental and physical labor and must allocate both units to one sector. This means, in particular,

[10] As shown in an earlier version of this paper, assuming that physical capital is a production factor of X_2 does not change the spirit of our results.

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[11]

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

It is assumed 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 income of a household is $w_t^M + w_t^F$, which is spent on consumption and raising children. 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 cost of a child is zw_t^F. If the husband spends time raising children, then the marginal cost of a child is zw_t^M. The household's budget constraint is therefore

$$\begin{aligned} w_t^F z n_t + s_t \le w_t^M + w_t^F \qquad & if \qquad zn_t \le 1 \\ w_t^F + w_t^M(zn_t - 1) + s_t \le w_t^M + w_t^F \qquad & if \qquad zn_t \ge 1 \end{aligned} \tag{4}$$

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

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

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

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

2.3 Optimality

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

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

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

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

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

2.3.1 Firms

Profit maximization of decentralized intermediate goods firms implies, by (2), that relative prices are:

$$\frac{p_{2,t}}{p_{1,t}} = \frac{1-\theta}{\theta}\left(\frac{X_1}{X_2}\right)^{1-\rho} = \frac{1-\theta}{\theta}\left(\frac{a\kappa_t^\alpha m_t + bl_{1,t}}{bl_{2,t}}\right)^{1-\rho}, \tag{7}$$

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

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

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

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

Wages are derived from (2) and reflect the marginal productivity of labor. For males we have

$$w_t^M = p_{1,t}b[(1-\alpha)a/b\kappa_t^\alpha + 1] \qquad if \qquad L_{1,t}^p > 0 \tag{10}$$

$$w_t^M = p_{2,t}b \qquad if \qquad L_{2,t}^p > 0, \tag{11}$$

which reflects mental and physical labor productivity in the first sector, and only physical labor productivity in the second sector. Similarly, female wage is

$$w_t^F = p_{1,t}(1-\alpha)a\kappa_t^\alpha \qquad if \qquad zn_t < 1, \tag{12}$$

which reflects mental labor productivity in the first sector.

2.3.2 Households

Household's maximizing problem yields

$$zn_t = \begin{cases} \gamma(1 + w_t^M/w_t^F) & if \quad \gamma(1 + w_t^M/w_t^F) \leq 1 \\ 2\gamma & if \quad 2\gamma \geq 1 \\ 1 & otherwise. \end{cases} \tag{13}$$

Equation (13) 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 very high gender wage gaps. But as the gender gap decreases women join the labor force and fertility decreases. When w_t^F approaches w_t^M, women spend a fraction 2γ of their time raising children. Finally, under $\gamma < 1/2$ the budget constraint (4) collapses to

$$s_t = (1 - zn_t)w_t^F + w_t^M \tag{14}$$

and (13) becomes

$$zn_t = \min\left\{\gamma\left(1 + w_t^M / w_t^F\right), 1\right\}. \tag{15}$$

2.4 Closed Economy

2.4.1 Static Equilibrium

The equilibrium of the integrated economy is determined by looking at two regimes separately. 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[12]

$$2 - \alpha \geq 1/\theta \tag{16}$$

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

$$\frac{w^M}{w^F} = 1 + \frac{b}{(1-\alpha)a\kappa_t^\alpha}. \tag{17}$$

This ratio determines female labor force participation $1 - zn_t$ through (15)

$$zn_t = \min\left\{\gamma\left(2 + \frac{b}{(1-\alpha)a\kappa_t^\alpha}\right), 1\right\}. \tag{18}$$

To determine equilibrium κ_t, combine male wages (10) and (11), prices (7), and the resource constraint for male labor $1 = l_{1,t} + l_{2,t}$ to get

$$(1-\alpha)\frac{a}{b}\kappa_t^\alpha + 1 = \frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\kappa_t^\alpha m_t + l_{1,t}}{1 - l_{1,t}}\right)^{1-\rho}. \tag{19}$$

[12] A sufficient condition for $l_{i,t} > 0$ 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. $(1-\alpha)\kappa_t^\alpha a/b + 1 > (1-\theta)/\theta\left(\kappa_t^\alpha a/b\right)^{1-\rho}$. If $\kappa_t^\alpha a/b \geq 1$ then this sufficient condition is implied by $(1-\alpha) \geq (1-\theta)/\theta$, or (16). If $\kappa_t^\alpha a/b < 1$ instead, the sufficient condition is implied by $1 > (1-\theta)/\theta$ and hence, again, by (16).

Further note that

$$l_{1,t} = m_t - (1 - zn_t) \tag{20}$$

so that equation (19) becomes

$$(1-\alpha)\frac{a}{b}\kappa_t^{\alpha} + 1 = \frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\kappa_t^{\alpha} m_t + m_t - (1 - zn_t)}{1 - m_t + (1 - zn_t)}\right)^{1-\rho}. \tag{21}$$

Equations (6), (18), and (21) 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 (21) can be written in terms of κ_t (substitute $m_t = k_t/\kappa_t$):

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

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 (18) to write (21) as

$$(1-\alpha)\frac{a}{b}\kappa_t^{\alpha} + 1 = \frac{1-\theta}{\theta}\left(\frac{\frac{a}{b}\frac{k_t}{\kappa_t^{1-\alpha}} + \frac{k_t}{\kappa_t} - 1 + \gamma\left(2 + \frac{b}{a}\frac{\kappa_t^{-\alpha}}{1-\alpha}\right)}{1 - \frac{k_t}{\kappa_t} + 1 - \gamma\left(2 + \frac{b}{a}\frac{\kappa_t^{-\alpha}}{1-\alpha}\right)}\right)^{1-\rho}. \tag{23}$$

Equations (22) and (23) determine the equilibrium κ_t in the first and second regime, respectively. Notice that expressions on the left of both equations are increasing in κ_t, while both terms on the right are decreasing in κ_t. This implies that κ_t is unique in both regimes. Moreover, the expressions on the right of (22) and (23) are increasing in k_t and we can write $\kappa_t(k_t)$ as an increasing function.

This means that, quite intuitively, a capital-rich economy has a higher capital-mental labor share than a capital scarce economy. When going back to equation (18), this observation shows also that the higher the capital stock k_t of an economy, the lower fertility zn_t is. As $\kappa_t(k_t)|_{k_t=0} = 0$, (18) 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 condition $\gamma\left(2+b/\left[(1-\alpha)a\kappa_o^\alpha\right]\right)=1$ with equation (22) and $\kappa_o = k_o/m_o$, this threshold can be shown to be

$$k_o = \theta\left(1-\gamma\right)\left(1-2\gamma+\gamma\frac{1-\alpha\theta}{1-\alpha}\right)^{-1}\left[\frac{(1-\alpha)(1-2\gamma)}{\gamma}\frac{a}{b}\right]^{-1/\alpha}. \tag{24}$$

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

These observations regarding the impact of the capital stock on fertility and on female labor force participation bring us to the dynamics of the model.

2.4.2 Dynamics

The dynamics of the model are governed by two endogenous variables: savings s_t and fertility n_t. With the notation in per-household terms, the ratio of saving and fertility gives the next period's capital stock, i.e. $k_{t+1} = s_t/n_t$. Combining the budget constraint (14) and fertility (15) and distinguishing the two regimes, we can write

$$k_{t+1} = \frac{s_t}{n_t} = \begin{cases} z w_t^M & if \;\; k_t < k_o \\ z\frac{1-\gamma}{\gamma}w_t^F & if \;\; k_t \geq k_o. \end{cases} \tag{25}$$

Equations (10) and (11) give the price ratio

$$\frac{p_{2,t}}{p_{1,t}} = (1-\alpha)\frac{a}{b}\kappa_t^\alpha + 1 \tag{26}$$

which, combined with the normalization (8), renders the price of the first intermediate good

$$p_{1,t} = \left(\theta^{1/(1-\rho)} + (1-\theta)^{1/(1-\rho)} \left(\frac{1}{(1-\alpha)\frac{a}{b}\kappa_t^\alpha + 1}\right)^{\rho/(1-\rho)}\right)^{(1-\rho)/\rho}.$$

With (10), (12) and (25) we thus have

$$k_{t+1} = \begin{cases} zb\left(\theta^{\frac{1}{1-\rho}}\left((1-\alpha)\frac{a}{b}\kappa_t^\alpha + 1\right)^{\frac{\rho}{1-\rho}} + (1-\theta)^{\frac{1}{1-\rho}}\right)^{\frac{1-\rho}{\rho}} & if \quad k_t < k_o \\ zb\frac{1-\gamma}{\gamma}\left(\theta^{\frac{1}{1-\rho}}\left((1-\alpha)\frac{a}{b}\kappa_t^\alpha\right)^{\frac{\rho}{1-\rho}} + (1-\theta)^{\frac{1}{1-\rho}}\left(\frac{(1-\alpha)\frac{a}{b}\kappa_t^\alpha}{(1-\alpha)\frac{a}{b}\kappa_t^\alpha+1}\right)^{\frac{\rho}{1-\rho}}\right)^{\frac{1-\rho}{\rho}} & if \quad k_t \geq k_o. \end{cases} \tag{27}$$

These expressions show that in both regimes, k_{t+1} is increasing in κ_t and thus, since κ_t is an increasing function in k_t, the schedule $k_{t+1}(k_t)$ of the dynamic system is described by an increasing function.

We can now make two observations, which jointly imply the existence of a steady state under the second regime. First, the variable κ_t determined by (22) or (23) as well as the threshold capital stock (24), is independent of z. Thus, given that z is sufficiently large, an economy with per-household capital stock $k_t = k_o$ from (24) experiences positive capital growth due to capital accumulation (27): its capital stock in period $t+1$ exceeds its capital stock of the previous period, i.e. $k_{t+1} > k_t$ holds. Second, as k_t grows unbounded, the ratio $\kappa_t/k_t = 1/m_t$ is bounded from above[13]. Thus, dividing the second line on the right hand side of equation (27) by k_t shows that k_{t+1}/k_t approaches zero as k_t grows unbounded. Together, these findings imply that, if z is sufficiently large, the dynamic system has a steady state in the second regime.

Our knowledge about the dynamics and the steady state of the system is sufficient to tell a simple story about economic development and female labor force participation. In an economy where capital is scarce, female labor force participation is zero. As time passes and per-household capital stock gradually accumulates, the rewards of formal employment for female workers increase relative to rewards for male workers. This closing of the gender wage

[13]See Appendix.

gap fosters female labor force participation and curbs fertility. Both effects accelerate per-household capital accumulation, which continues under the second regime up to the point where the economy reaches its steady state.

2.5 International Trade

International trade in goods induces specialization at the country level so that countries expand some sectors while contracting others. If, as in the current model, sectors differ in factor intensity, international specialization affects relative factor prices within each country. In the following paragraphs, we explore these effects of trade, particularly its impact on the gender wage gap and hence on 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 price of the two goods by $\pi_t = p_{2,t}/p_{1,t}$, the ratio of male to female wage by $\omega_t = w_t^M/w_t^F$, and the relative population size of Foreign to Home by $\lambda_t = L_t^*/L_t$. 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 t. For later use, we define the set of all possible factor distributions in a world as:

$$FD_t = \left\{(\lambda_t, k_t, k_t^*) \mid \lambda_t \in [0, \infty];\ k_t, k_t^* \geq 0 \text{ and } \left(k_t + \lambda_t k_t^*\right)/(1+\lambda_t) = \bar{k}_t\right\}, \tag{28}$$

where $\bar{k}_t$ is the average per household capital stock of the world economy.

2.5.1 Factor Price Equalization

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

$$FPES_t = \left\{(\lambda_t, k_t, k_t^*) \in FD_t \mid w^M = w^{*,M},\ w^F = w^{*,F},\ r^F = r^*\right\}. \tag{29}$$

(Remember that the absence of superscript ^{A} indicates equilibrium variables under free trade – *e.g.* at w^M, $w^{*,M}$ etc.) 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.[14] 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

Under costless trade, the following statement holds: Factor prices equalize $\Leftrightarrow \kappa_t^* = \kappa_t$.

Proof. See Appendix. ■

The proposition shows that $\kappa_t = \kappa_t^*$ implies $\omega_t = \omega_t^*$, a regime in which fertility, determined by (15), equalizes in both countries: $zn_t = zn_t^* = z\bar{n}_t$.[15] Combined with $\kappa_t = \kappa_t^* = \bar{\kappa}_t$ this leads to:

$$\bar{\kappa}_t = \frac{k_t}{l_{1,t} + 1 - z\bar{n}_t} = \frac{k_t^*}{l_{1,t}^* + 1 - z\bar{n}_t}. \tag{30}$$

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. The constraints $l_{1,t}, l_{2,t}^* \in [0, 1]$ lead to a restriction on capital stock conditions for factor price equalization:

$$(1 - z\bar{n}_t)\bar{\kappa}_t \leq k_t, k_t^* \leq (2 - z\bar{n}_t)\bar{\kappa}_t \tag{31}$$

by the resource constraint. Capital stocks of both countries must add up to the aggregate world capital stock, i.e., $\bar{k}_t = (k_t + \lambda_t k_t^*) / (1 + \lambda_t)$. Thus, the $FPES_t$ is described by (31)

[14] 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.

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

and

$$k_t = (1 + \lambda_t)\bar{k}_t - \lambda_t k_t^*. \tag{32}$$

Using the concise graphical representation from Helpman and Krugman (1985), Figure 2 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. The upper panel of Figure 2 shows the case $z\bar{n}_t < 1$, where a minimum amount of capital is required in each country to keep female labor force productive in the first sector. The lower panel shows the case $z\bar{n}_t = 1$. In this case, a country may entirely lack capital while the world economy is still at its efficiency frontier, replicating the equilibrium of the integrated economy.

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

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

while

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

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

We can further compare the trade equilibrium with the respective autarky equilibria: notice that $1 - z\bar{n}_t \leq m_t < m_t^*$ implies $l_{1,t}^* > 0$ so that $\omega_t^* = 1 + b/(a(1-\alpha))\bar{\kappa}_t^{-\alpha}$ and (18) applies for Foreign. As $\omega_t^* = \omega_t$ and since $\kappa_t(k_t)$ is an increasing function, we use (18) again to conclude:

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

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

Both 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 wage gap $\omega_t^{(*)}$. In autarky and under factor price equalization, this wage gap is determined by the relative productivities in the X_1-sector via (18) and ultimately by the capital-mental labor ratio $\kappa_t^{(*)}$. When international specialization induces Home to contract its X_1-sector and expand its X_2-sector, male workers move from the first to the second sector, taking their mental labor with them. Thus, they increase the ratio κ_t and hence female labor force participation $(1 - zn_t)$. Conversely, when Foreign workers react to trade-induced international price shifts and move from the second to the first sector, they dilute the capital-mental labor share κ_t^*, which increases the wage gap and decreases female labor force participation.[16]

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 wage gap is a function of only the capital-mental labor ratio $\kappa_t^{(*)}$. It may occur to the reader that international trade can induce male workers of one country to entirely abandon the first sector, while, at the same time, factor prices and the wage gap in particular do not equalize in both countries. If this is the case, the one-to-one relationship between κ_t and

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

zn_t described by (18) does not hold and the mechanism described above ceases to apply. Consequently, our results under factor price equalization cannot be expected to hold under each and every factor distribution $(\lambda_t, k_t, k_t^*) \in FD_t$. The extent to which they generalize beyond factor price equalization is the subject of the next subsection.

2.5.2 Beyond Factor Price Equalization

Let us begin the general case of international trade by focusing on one country, for example, Home, with exogenous relative world prices π_t – i.e., assume, for the moment, Home to be a small open economy. For this exercise, we abandon Home's role as the capital scarce country. When world prices coincide with Home's autarky price π_t^A, we have $l_{1,t}, l_{2,t} > 0$, as argued in the case of the closed economy. Thus, by wages (10), (11), and (12) we find that:

$$\begin{aligned} \omega_t &= \pi_t \frac{b/a}{1-\alpha} \kappa_t^{-\alpha} && (33) \\ \pi_t &= (1-\alpha) \frac{a}{b} \kappa_t^{\alpha} + 1 && (34) \end{aligned}$$

hold for π_t in a small neighborhood of π_t^A. Combine (33) and (34) to verify that in this neighborhood, the wage gap

$$\omega_t = \frac{\pi_t}{\pi_t - 1} \qquad (35)$$

is decreasing in π_t and zn_t is also decreasing by (15). Since κ_t is increasing in π_t by (34), $m_t = l_{1,t} + 1 - zn_t$ must be decreasing in π_t, which finally means that $l_{1,t}$ is decreasing in π_t. These relations hold as long as $l_{1,t}, l_{2,t} > 0$ apply. Thus, by the constraints $l_{1,t} \in [0, 1]$, there are thresholds $\underline{\pi}$ and $\bar{\pi}$ with $\underline{\pi} < \pi_t^A < \bar{\pi}$ so that for $\pi_t < \underline{\pi}$, we have $l_{1,t} = 1$ and κ_t as well as the wage gap ω_t defined by (17) are constant. Conversely, for $\pi_t > \bar{\pi}$, we have $l_{1,t} = 0$ in which case (33) holds and $\kappa_t = k_t/(1 - zn_t)$ and (15) imply:

$$\frac{\omega_t}{(1 - \gamma(1 + \omega_t))^{\alpha}} = \pi_t \frac{b/a}{1-\alpha} k_t^{-\alpha}. \qquad (36)$$

This equation defines ω_t as an increasing function of π_t. Finally, at $\pi_t \to \infty$ equation (36) implies $\omega_t \to (1-\gamma)/\gamma$.

Figure 3 summarizes these findings of the function $\omega_t(\pi_t)$. For small π_t, the wage gap ω_t is constant. For the intermediate range $\pi_t \in (\underline{\pi}, \bar{\pi})$, the wage gap $\omega_t(\pi_t)$ is decreasing but for $\pi_t > \bar{\pi}$ it is increasing. By the generic relation (15), these swings in ω_t are paralleled by swings in zn_t.

Now consider the Home economy facing relative world prices $\pi_t < \pi_t^A$. This means that, relative to autarky, the wage gap ω_t increases and, 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.[17] If, instead, $\pi_t > \pi_t^A$, there are two possible outcomes. First, if π_t is not too large, then the effect of trade is a reduction in the wage gap ω_t and thus a decrease in fertility n_t and an increase in female labor force participation $(1 - zn_t)$. Second, if π_t is sufficiently large, then trade induces an increase in ω_t and n_t and a decrease in $(1 - zn_t)$. In Figure 3, the threshold that separates the two cases is labeled π_u. In either case, trade contracts the X_1-sector and expands the X_2-sector.[18]

Now, return to the trade equilibrium between capital scarce Home and capital abundant Foreign. The autarky prices of both countries satisfy (34), implying $\pi_t^A < \pi_t^{*,A}$, while the world price under free trade π_t must lie between the respective autarky prices:

$$\pi_t^A \leq \pi_t \leq \pi_t^{*,A}. \tag{37}$$

Thus, trade (weakly) increases relative prices π_t in Home while it (weakly) decreases them in Foreign. With this observation, we can apply the insights of the analysis above. For capital

[17]To see this, notice that $\pi_t < \pi_t^A$ implies $l_{1,t} > l_{1,t}^A$ and, as (34) holds, $\kappa_t < \kappa_t^A$. This, in turn leads to $m_t > m_t^A$ so that total output in the first sector $ak_t^\alpha m_t^{1-\alpha} + bl_{1,t}$ rises relative to autarky. Output of the second sector $b(1 - l_{1,t})$ drops.

[18]Observe that $\pi_t > \pi_t^A$ implies $l_{1,t} < l_{1,t}^A$ so output in the second sector $b(1 - l_{1,t})$ expands in both cases. Further, for $\pi_t < \bar{\pi}$ (34) holds, implying $\kappa_t > \kappa_t^A$ or $m_t < m_t^A$. Any increase in π_t above $\bar{\pi}$ reduces female labor $1 - zn_t$ while $l_{1,t} = 0$ continues to hold. Thus, $m_t < m_t^A$ in this range, too. Together, this means that output in the first sector $ak_t^\alpha m_t^{1-\alpha} + bl_{1,t}$ falls.

abundant Foreign, trade unambiguously causes a (weak) increase in the wage gap ω_t and thus a drop in female labor force participation. We can therefore generalize the first part of our result derived under factor price equalization. The country which, by international specialization, expands the sector suitable for female employment experiences a decrease in female labor force participation.

For capital scarce Home, however, trade induces a decrease in the wage gap ω_t and an increase in female labor force participation if and only if π_t is not too high (i.e., $\pi_t \leq \pi_u$ holds). In this restricted case, we recover the second part of the result derived under factor price equalization. The country which contracts the sector suitable for female labor experiences an increase in female labor force participation.

This second observation is a non-trivial generalization of the parallel result under factor price equalization. To verify this statement, use that under free trade $l^*_{1,t} > 0$ and $l_{2,t} > 0$ hold so that, by (10) and (11)

$$(1-\alpha)\frac{a}{b}(\kappa^*_t)^\alpha + 1 \geq \pi_t \geq (1-\alpha)\frac{a}{b}\kappa^\alpha_t + 1 \tag{38}$$

holds. Proposition 1, however, states that factor price equalization requires $\kappa_t = \kappa^*_t$, implying $\pi_t = (1-\alpha)\frac{a}{b}\kappa^\alpha_t + 1$. By construction of $\bar{\pi}$, however, all world equilibria with $\pi_t \in (\bar{\pi}, \pi_u)$ are characterized by equality $\pi_t > (1-\alpha)\frac{a}{b}\kappa^\alpha_t + 1$, implying that factor prices do not equalize. Since finally, by construction of π_u we have $\omega_t > \omega^A_t$ for all equilibria with $\pi_t \in (\bar{\pi}, \pi_u)$ 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 (28) and (29) to state the following proposition.

Proposition 2

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

(ii) There is a set $S_t \subset FD_t$ with $FPES_t \subsetneqq S_t$ 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.

2.5.3 Dynamics under Trade

The dynamics of the model under free trade are again driven by two key variables, savings s_t and fertility n_t. Per-household capital stocks of either country follow the generic dynamic system equivalent to (25), now expanded to:

$$k_{t+1}^{(*)} = \begin{cases} z w_t^{M,(*)} & if \quad z n_t^{(*)} = 1 \\ z \frac{1-\gamma}{\gamma} w_t^{F,(*)} & if \quad z n_t^{(*)} < 1 \end{cases} \tag{39}$$

To calculate the respective wages (10) - (12), we can use the final good normalization (8) and the definition of π_t to derive:

$$p_{1,t} = \left(\theta^{\frac{1}{1-\rho}} + (1-\theta)^{\frac{1}{1-\rho}} \pi_t^{\frac{-\rho}{1-\rho}} \right)^{(1-\rho)/\rho} \quad \text{and} \quad p_{2,t} = \left(\theta^{\frac{1}{1-\rho}} \pi_t^{\frac{\rho}{1-\rho}} + (1-\theta)^{\frac{1}{1-\rho}} \right)^{(1-\rho)/\rho} \tag{40}$$

These defined wages and dynamic system, (39), give rise to the following observations

Proposition 3

(i) $z n_t^* \leq z n_t$.

(ii) $k_{t+1}^* \geq k_{t+1}$.

(iii) If $\alpha(\theta/(1-\theta))^{\frac{-1}{1-\rho}} \geq (1-2\gamma)/\gamma$ *holds then* $k_{t+1} \geq k_{t+1}^A$.

(iv) $k_{t+1}^*/k_{t+1} \leq k_{t+1}^{*,A}/k_{t+1}^A$.

Proof. See Appendix. ■

Proposition 3 (i) and (ii) show that trade cannot reverse the order of countries regarding population growth or capital abundance. The capital rich country has always weakly lower fertility rates, higher female labor force participation and faster pace of per-household capital accumulation.

Proposition 3 (iii) shows that, given that the first sector is sufficiently large (i.e., $1-\theta$ is sufficiently small), trade unambiguously accelerates the pace of capital accumulation in the capital scarce country. It is worth emphasizing that this result also holds in the case where world prices π_t are very large and all men in Home work in the X_2-sector while female labor participation drops relative to autarky ($\pi_t > \pi_u$ in Figure 3). Even in this case, where a reduced female labor force participation depresses savings and increased population growth dilutes the following period's per household capital stock, the gains from trade are sufficient to grant a net increase in per-household capital accumulation relative to autarky. We cannot, however, make a parallel statement for the capital rich economy, for which the effect of trade on capital accumulation is ambiguous. Indeed, it can be shown that for capital accumulation in the rich economy, the positive forces stemming from the gains of trade might either dominate or be dominated by the adverse effect of reduced female labor force participation and higher fertility.

Finally, Proposition 3 (iv) makes a relative statement about the countries' capital accumulation. Trade cannot accelerate capital accumulation in the rich country by more than it accelerates it in the poor country. In particular, the proposition shows that trade spurs convergence of per-household capital stocks. At the same time, using Proposition 3 (ii) and (iv), a simple induction argument leads to $k^*_{t+\tau}/k_{t+\tau} \leq k^{*,A}_{t+\tau}/k^A_{t+\tau}$ for all $\tau \geq 0$ and hence:

$$\lim_{t\to\infty} k_t = \lim_{t\to\infty} k^*_t = \tilde{k}.$$

Since in the limit, factor endowments between countries equalize, the motives to trade disappear. Consequently, the limit $\tilde{k}$ is equal to the limit of the closed economy: $\tilde{k} = k$, where k is the steady state capital stock of the closed economy.

Summarizing Proposition 3, international trade fosters convergence in fertility, labor force participation, and per-household capital stocks.

2.6 Technological Progress

The reduction in the gender wage gap is often attributed to technological change. Thus, Welch (2000), Gosling (2003) and Black and Spitz-Oener (2007) argue that the increase in the market price for women's labor was brought about by a relative increase in the valuation of skill (mental labor endowments), which is, at least in part, explained by technological change. Galor and Weil (1996) show how technological change can eliminate poverty traps, characterized by high fertility, low female labor force participation and low per-household capital stocks. They argue that "technological progress will eventually eliminate such a development trap, leading to a period of rapid output growth and a rapid fertility transition" (p. 383).

Another popular hypothesis rests on demand shifts in favor of goods whose production is more intensive in skill or, more generally, in female labor inputs. The mechanism outlined above, in which, male workers searching for the highest return to their labor crowd out women in the labor market sheds some doubt on the generality of these pro-growth effects. Indeed, we show next that the effect that leads to a decrease in female labor force participation and an increase in fertility in response to the expansion of the females' comparative advantage sector operates under technological change and shifts in demand as well.

For the formal analysis of technological change and demand shifts, we return to the closed economy. To incorporate technological change biased towards the sectors that generate demand for female labor, we rewrite the production functions (2) as:

$$\begin{aligned} X_1 &= \mu \left[a K_t^{\alpha} (L_t^m)^{1-\alpha} + b L_{1,t}^p \right] \\ X_2 &= b L_{2,t}^p \end{aligned} \tag{41}$$

so that growth of the parameter $\mu \geq 1$ mimics technological progress that is biased towards the first sector. As a result of incorporating μ into our framework (23) becomes[19]

$$\frac{\theta}{1-\theta}\mu^{\rho}\left[(1-\alpha)\frac{a}{b}\kappa_t^{\alpha}+1\right]=\left(\frac{\frac{a}{b}\frac{k_t}{\kappa_t^{1-\alpha}}+\frac{k_t}{\kappa_t}-1+\gamma\left(2+\frac{b}{a}\frac{\kappa_t^{-\alpha}}{1-\alpha}\right)}{1-\frac{k_t}{\kappa_t}+1-\gamma\left(2+\frac{b}{a}\frac{\kappa_t^{-\alpha}}{1-\alpha}\right)}\right)^{1-\rho} \tag{42}$$

While the right hand side of (42) is decreasing in κ_t, the left hand side of (42) is increasing in κ_t and in μ, for $\rho \in (0,1)$. This implies that an increase in μ decreases the equilibrium level of κ_t, which, in turn, decreases female's productivity relative to male productivity, widens the gender wage gap and curbs female labor force participation.

After reading the previous subsections, the intuition for this result is straightforward. An increase in μ increases male productivity in the first sector relative to the second sector. As long as the elasticity of substitution between X_1 and X_2 is greater than one, the relative price π decreases but the decrease is less than the increase in μ. As a result, male wage increases in the first sector, inducing male workers to move from the second sector to the first sector. This increases mental labor employed in the first sector and dilutes κ so that women's relative productivity declines, driving women out of formal employment into the child-rearing.

A similar mechanism applies under demand shifts towards the first good, equivalent to an increase in the parameter θ (compare (1)). Again, equation (42) shows that an increase in θ is followed by a decrease in κ_t, which curbs women's productivity by more than men's, widens the wage gap and thus decreases female labor force participation while fostering fertility.

Thus, our model shows that neither a technological change biased towards sectors with a high demand for female labor nor demand shift towards goods of these sectors necessarily generates increases in female labor participation. The resulting increase in fertility generally counters the pro-growth effects.

[19]Under $\mu \geq 1$ condition (16) is sufficient for $l^p_{1,t} > 0$ to hold, i.e., male employment in the first sector is positive.

3 Empirical Evidence

Our theory predicts an asymmetric impact of trade liberalization on the labor markets of capital rich and capital scarce economies: while trade lowers female labor force participation in the former, it tends to increase it in the latter. We like to think of our theory in the context of long run growth and frame it with a model of demographic transition. In light of data limitations, however, 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[20].

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.[21] 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 by more than a factor of 3 between 1990 and 2007, while Mexico's share in U.S. total trade rose by more than a factor of 2 (Figure 4). 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.

[20]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) puts forward that Mexico's unilateral tariff reduction in the late 1980s and its abandoning of the exchange rate peg explains the larger part 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.

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

3.1 Data

We rely on three different data sources. First, we use data from the March Current Population Survey conducted by the Integrated Public Use Microdata Series (IPUMS-CPS).[22] 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 and usual hours worked (to compute total hours worked). Table 1 provides descriptive statistics for female and male labor for the years 1990/91 and 2006/07. As is visible in Table 1, while female labor force participation has increased, male labor force participation has decreased during the NAFTA episode. Second, we use the "Origin of Movement" database administered by WISER,[23] which covers export data by state and destination country from 1988 onward. These data are disaggregated by good categories (SIT2 from 1988 to 2000; NAICS from 1997 onward). Third, we use the Bureau of Economic Analysis for GDP by state data.[24]

3.2 The Empirical Model

In our empirical exercise we concentrate on one side of our theory and aim at identifying 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 share across states.[25]According to our theory, a higher exposure to trade with Mexico induces lower female labor force participation in

[22]King, Ruggles, Alexander, Leicach and Sobek (2009).

[23]World Institute for Strategic Economic Research; data available under http://www.wisertrade.org. Cassey (2006) gives a good introduction to the data and their limitations.

[24]data available under http: http://bea.doc.gov/regional/.

[25]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 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 works frictionless. We nevertheless expect to capture labor markets effects to the extent that frictions of labor movement related to geographical distance impede a full equalization of factor prices across U.S. states.

the different U.S. states. Analyzing this relation on the state level, our reduced form model takes the following form

$$y_{st} = \delta_s + \alpha t + \beta Trade_{st} + X'_{st}\gamma + u_{st} \tag{43}$$

where s indicates U.S. states and t periods. The dependent variable y_{st} is the female labor share, $Trade_{st}$ is trade volume per output and δ_s denotes a full set of state dummies. Apart form a time-trend we control for a vector of covariates X'_{st} chosen by economic intuition but unrelated to our theoretical model. Our initial period is 1990-1, denoted by $t = 0$, while the end period is 2006-7, denoted by $t = 1$.[26]

Taking differences eliminates the state fixed effects and the empirical model (43) becomes

$$\Delta y_s = \alpha + \beta \Delta Trade_s + \Delta X'_s\gamma + u_{s1} - u_{s0} \tag{44}$$

where for any variable z_{st} the notation Δz_s indicates the change over time ($\Delta z_s = z_{s1} - z_{s0}$). Our theory predicts that the estimate of β in (44) is negative.

Concerned with the possibility that labor market conditions in the U.S. can constitute a form of comparative advantage and thus drive trade volumes, we slightly modify the gravity equation of the trade literature and instrument $Trade_{st}$ by distance to Mexico.[27] Thus, our first stage regression is:

$$Trade_{st} = \varrho_s + \mu\ t + \theta\ d_s t + X'_{st}\ \rho + \nu_{st} \tag{45}$$

where ϱ_s denotes a full set of state dummies and d_s is distance of state s to Mexico. By

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

[27] More precisely, we regress trade volume as a percentage of GSP 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. Our justification is the fit of the data. For a more elaborate and elegant way for instrumenting trade with distance see Feyrer (2009).

taking differences our first stage regression becomes:

$$\Delta Trade_s = \mu + \theta\ d_s + \Delta X_s'\ \rho + \nu_{s1} - \nu_{s0} \tag{46}$$

Figure 5 illustrates that distance is strongly correlated with the increase in trade share, satisfying a first necessary condition for being a valid instrument.[28]

3.3 Control Variables

To control for differential business cycle effects across states we include log per capita "Gross State Product" (GSP) and the unemployment rate. We also control for average education level for females, which is positively correlated with female labor share.[29] Further, we include the share of Mexican immigrants, which might either depress female labor participation – *e.g.* due to cultural differences reducing gender labor market participations[30] – 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.

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 con-

[28]By our identifying assumption, distance to Mexico does not impact the change in female labor shares across U.S. states through other channels than bilateral trade. To lend support to this assumption we examine the quality of distance as an instrument by comparing its explanatory power 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, in which U.S.-Mexican trade was stagnant, which we simply label the "pre-NAFTA episode" (Figure 4). To this end, we employ the 1 percent 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 period, and 1980, 1990 and 2000 for the NAFTA period. Table A-1 (see Appendix) summarizes these reduced form regressions of female labor force participation directly on distance in the two episodes and shows that during the NAFTA period the coefficient of distance is positive and significant while in the pre-NAFTA period is negative and sometimes insignificant, which is consistent with our story.

[29]We define two categories of education. First, educated individuals who have at least some college 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.

[30]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.

verges across states. Hence, the initial levels of female labor share is highly correlated with its changes. To account for this convergence effect, we include initial level of female labor force participation in the controls when estimating (44). A problem with this control variable, however, is that it is correlated with the error term $u_{i1} - u_{i2}$ in (44) through equation (43), wherefore we instrument it with lagged female labor participation (values from 1980/81).

3.4 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. The restriction to exports is due to the fact that import data per state are not available.[31] Distance is 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 it to be the average of 1980 and 1981 and the change in trade with Mexico. Our focus, however, lies 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 our interest is the one on change in trade with Mexico (β). All of its estimates have the expected negative sign and are significant on the one percent confidence level. Column 3, indicates that a one percent increase in trade share with Mexico (as

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

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 predicted by convergence forces.[32]

3.5 Robustness

We next conduct some robustness check 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 5), 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% level (5% in column 3).

We are also concerned about our definition of trade shares, since Cassey (2006) 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).[33] Results show that neither the point estimates nor the significance level are affected.

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

Next we replace the definition of our dependent variable from share of hours to relative

[32] Table 2 shows that the OLS estimate is larger than IV estimate. One possible interpretation from this difference, which is consistent with our theory is that higher female labor force participation induces a higher relative advantage in the capital intensive sector which implies higher international specialization and trade.

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

employment. This obviously eliminates the important intensive margin of individuals' labor market participation. 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 are 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 A-2.[34] 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 hours: estimates are insignificant, positive and around zero.

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.

Interestingly, Our mechanism also applies in the case of technological progress, which is biased towards female labor. In particular, technological progress biased towards FRAS increases the wages in this sector. This increase in wages attracts male workers who leave the

[34]Column 2, 4, 6 and 8 in Table A-2 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.

MRAS, an effect that can be strong enough to drive female workers out of formal employment. In this way, technological progress biased towards female labor might curb female labor force participation.

Turning to the dynamics, our model suggests that international trade fosters per-household capital growth in the capital scarce economy. In the capital abundant economy, however, the impact of international trade on capital growth is ambiguous. Although international trade hinders female labor force participation and increases fertility, domination of these adverse effects by positive forces stemming from gains from trade may occur. In both cases, our model suggests that trade cannot accelerate capital accumulation in the rich country by more than it accelerates capital accumulation in the poor country and, thus, our theory predicts convergence of per-household capital stocks.

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. 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.

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Figures & Tables

Figure 1: Relative Wages, United States 1800-1990. Source: Galor (2005).

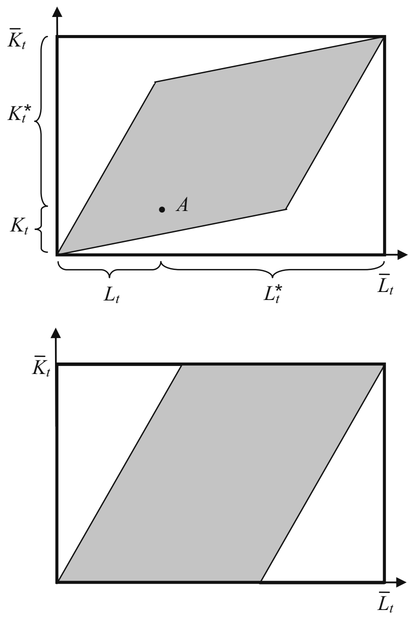


Figure 2: Factor Price Equalization Set

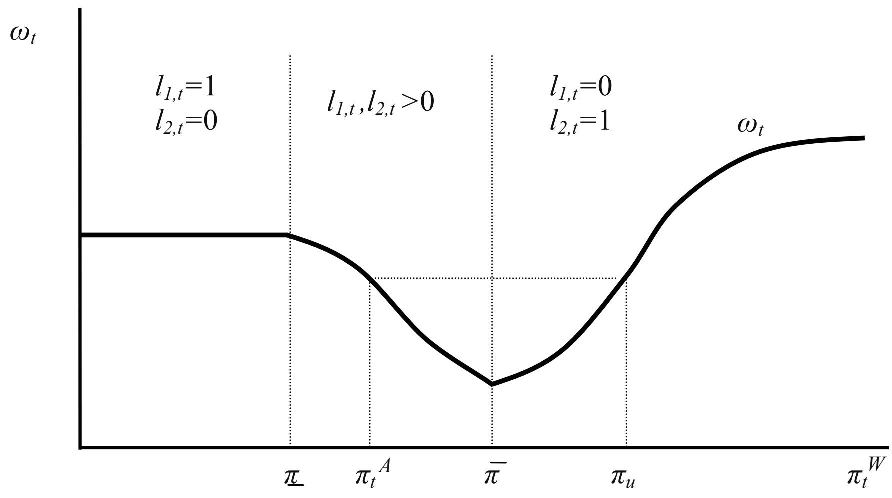


Figure 3: Wage Gap and World Price

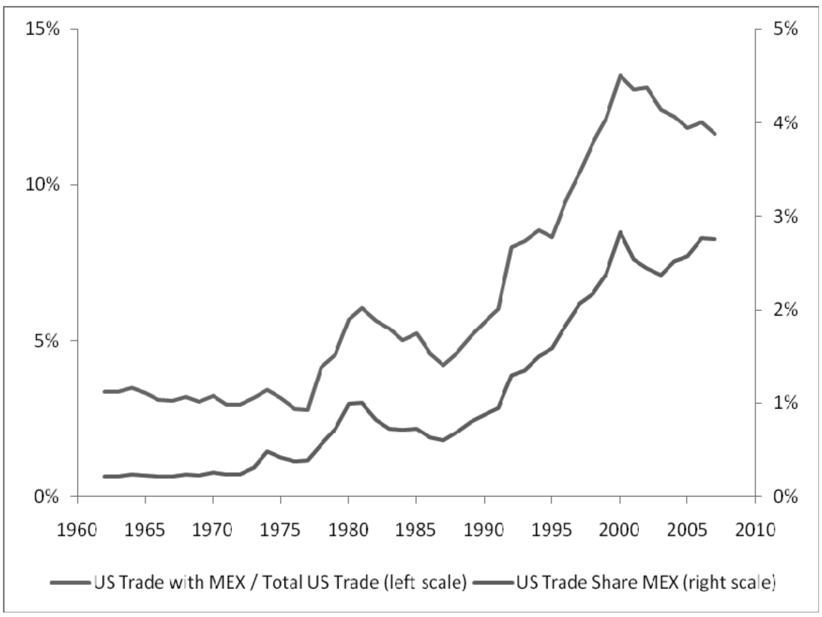
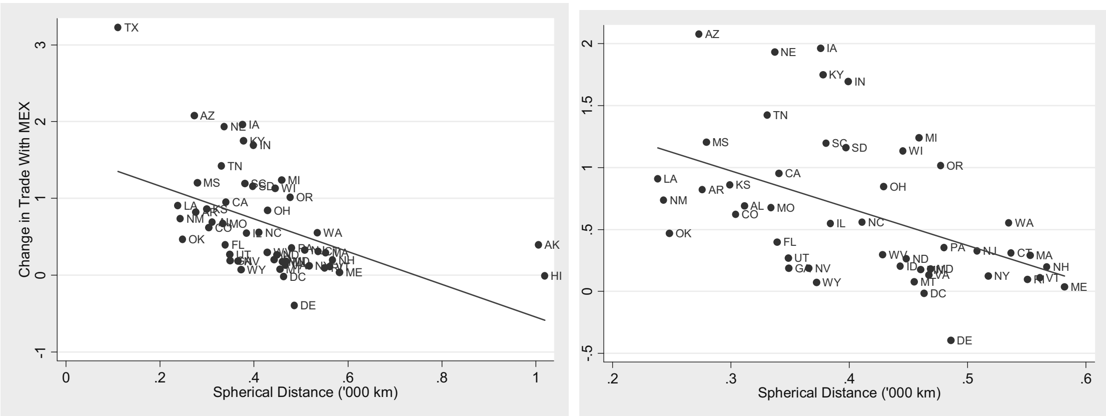


Figure 4: U.S. Trade Share – Imports plus Exports over GDP – with Mexico (red line, right scale) and Mexico's Share of U.S. Trade Volumes (blue line, left scale). Source: (1) Nominal GDP: are from Heston et al. (2006) and (2) US imports from and export to Mexico are from Feenstra et al. (2005) for the period 1962 - 2000 and from United States International Trade Commission for the period 2001 - 2008



slope = -2.13 t-statistic= -3.92

slope = -3 t-statistic= -3.75

Figure 5: Change in Trade with Mexico by State (1990-2007). left Panel: all states; right panel: excluding Alaska, Hawaii and Texas.

Table 1: Characteristics of U.S. State, 1990/91 and 2006/07

	1990/91	2006/07
FEMALE		
Education (%)	39.38 (5.59)	56.55 (5.36)
Weekly hours worked	22.77 (1.92)	24.24 (1.84)
Employment (%)	65 (5.2)	67 (4.7)
MALE		
Education (%)	41.21 (6.36)	50.87 (5.92)
Weekly hours worked	32.92 (1.89)	32.2 (1.81)
Employment (%)	78 (3.6)	77 (4.2)
State		
per-capita GSP	28321 (11307)	37968 (13881)
Trade share (%)	0.53 (0.98)	1.21 (1.51)
Unemployment (%)	6.34 (1.36)	4.82 (1.09)
Mexican Immigrants (%)	1.47 (3.03)	2.94 (3.69)

NOTE.-Gross state standard deviations are in parentheses. Data for education, labor participation 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

	Dependent Variable: change in females share in average hours worked					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Trade with Mexico	-0.280	-0.806^{*}	-1.506^{***}	-1.879^{***}	-1.268^{***}	-1.259^{***}
	(0.201)	(0.409)	(0.420)	(0.689)	(0.424)	(0.445)
FLFP in 1980/81	-0.248^{***}					
	(0.060)					
FLFP in 1990/91			-0.635^{***}	-0.760^{***}	-0.629^{***}	-0.601^{***}
			(0.157)	(0.179)	(0.129)	(0.152)
Δ ln(GSP per capita)				0.020		
				(0.016)		
Δ Unemplyment				0.490^{**}		
				(0.213)		
Δ Females' Education					0.125^{**}	
					(0.051)	
Δ Mexican immigrants						-14.010
						(12.342)
		First-Stage Coefficients (Dependent Variable: Δ Trade)				
Distance		-2.134^{***}	-2.021^{***}	-1.989^{***}	-2.004^{***}	-1.850^{***}
		(0.544)	(0.581)	(0.584)	(0.597)	(0.629)
		First-Stage Coefficients (Dependent Variable: FLFP in 1990/91)				
FLFP in 1980/81			0.529^{***}	0.563^{***}	0.527^{***}	0.531^{***}
			(0.066)	(0.069)	(0.063)	(0.068)
Number of obs	51	51	51	51	51	51
Estimation 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. 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

Dependent Variable:	Change in						
	Females share in average hours worked						Relative Employment
	Excluding			Trade in Manufacture	Distance in minutes	Married Couples	
	TX (1)	Hi&AK (2)	TX, HI&AK (3)	(4)	(5)	(6)	(7)
Δ Trade with Mexico	-1.917^{***} (0.500)	-1.103^{***} (0.331)	-1.363^{**} (0.519)	-1.631^{***} (0.502)	-1.559^{***} (0.442)	-1.130^{**} (0.427)	-4.929^{**} (2.131)
FLFP in 1990/91	-0.684^{***} (0.170)	-0.629^{***} (0.162)	-0.655^{***} (0.175)	-0.599^{***} (0.150)	-0.671^{***} (0.671)	-0.539^{**} (0.250)	-0.600^{**} (0.264)
	First-Stage Coefficients (Dependent Variable: Δ Trade)						
Distance	-1.409^{**} (0.540)	-3.866^{***} (0.802)	-2.837^{***} (0.815)	-1.871^{***} (0.546)	-1.864^{***} (0.538)	-2.112^{***} (0.568)	-1.891^{***} (0.608)
	First-Stage Coefficients (Dependent Variable: FLFP in 1990/91)						
FLFP in 1980/81	0.532^{***} (0.067)	0.555^{***} (0.060)	0.552^{***} (0.060)	0.529^{***} (0.066)	0.545^{***} (0.062)	0.544^{***} (0.075)	0.593^{***} (0.107)
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. The dependent variables, relative employment described in column 7 is the ratio of females employment over males employment. See the note to Table 1 for additional sample details and variables definition.

APPENDIX

Proofs & Tables

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 (23) 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 (21) by κ_t^α to get

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

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

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

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

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

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

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

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. ■

Proof of Proposition 3. (i) By (15) it is sufficient to show $\omega_t^* \leq \omega_t$. Since free trade implies $l_{1,t}^* > 0$ and $l_{2,t} > 0$ we have $\omega_t = \pi_t b / [a(1-\alpha)\kappa_t^\alpha] \geq 1 + b/[a(1-\alpha)\kappa_t^\alpha]$ and $\omega_t^* = 1 + b/[a(1-\alpha)(\kappa_t^*)^\alpha] \geq \pi_t b/[a(1-\alpha)(\kappa_t^*)^\alpha]$. Combining these relations gives

$$\frac{\omega_t^*}{\omega_t} \leq \frac{\pi_t + \omega_t^*}{\pi_t + \omega_t}$$

and proves statement (i).

(ii) By (i) and (15) we have $zn_t^* \leq zn_t$ and can distinguish two cases. The first where $zn_t = 1$ gives with (39) and $l_{2,t} > 0$

$$\frac{k_{t+1}^*}{k_{t+1}} \geq \frac{w^{M,*}}{w^M} \geq \frac{p_{2,t}b}{p_{2,t}b} = 1$$

If instead $zn_t < 1$ (i) implies $zn_t^* < 1$ so that (39)

$$\frac{k_{t+1}^*}{k_{t+1}} = \frac{w^{F,*}}{w^F} = \frac{\omega_t}{\omega_t^*}\frac{w^{M,*}}{w^M} \geq \frac{w^{M,*}}{w^M} = 1$$

where we used (i) in the first inequality and the second inequality follows as above.

(iii) If $zn_t^A = 1$ we have

$$\frac{k_{t+1}^A}{k_{t+1}} \leq \frac{w^{M,A}}{w^M} = \frac{p_{2,t}^A b}{p_{2,t}b} \leq 1$$

If, instead, $zn_t^A < 1$ then $zn_t < 1$ (from (35) as long as $l_{1,t} > 0$ and $m_t > 0$ otherwise) and

$$\frac{k_{t+1}^A}{k_{t+1}} \leq \frac{w^{F,A}}{w^F} = \frac{\omega_t}{\omega_t^A}\frac{w^{M,A}}{w^M}$$

For the case $\omega_t \leq \omega_t^A$ (or $\pi_t \leq \pi_u$ in Figure 3) this proves the claim. If instead $\omega_t > \omega_t^A$ we use $\kappa_t = k_t/(1 - zn_t)$ and (15) to write

$$\kappa_t \left(1 - \gamma\left(1 + \pi_t \frac{b/a}{1-\alpha}\kappa_t^{-\alpha}\right)\right) = k_t$$

and take implicit derivatives

$$\frac{d\kappa_t}{d\pi_t} = \kappa_t \frac{1}{1-\alpha} \frac{\gamma}{(1-\gamma)a/b\kappa_t^\alpha - \gamma\pi_t}$$

At the same time (40) leads to

$$\frac{dp_{1,t}}{d\pi_t} = -p_{1,t}^{1-\frac{\rho}{1-\rho}} \left(\frac{1-\theta}{\pi_t}\right)^{\frac{1}{1-\rho}}$$

Thus,

$$\frac{d}{d\pi_t} \ln\left(p_{1,t}\kappa_t^\alpha\right) = \frac{\alpha}{1-\alpha} \frac{\gamma}{(1-\gamma)a/b\kappa_t^\alpha - \gamma\pi_t} - \left(\left(\frac{\theta}{1-\theta}\right)^{\frac{1}{1-\rho}} \pi_t^{\frac{\rho}{1-\rho}} + \pi_t^{\frac{-\rho}{1-\rho}}\right)^{-1} \pi_t^{-1}$$

A sufficient condition for this expression to be positive is

$$\frac{\alpha}{1-\alpha} \frac{\gamma}{\pi_t^{-1}(1-\gamma)a/b\kappa_t^\alpha - \gamma} > \frac{1}{\left(\frac{\theta}{1-\theta}\right)^{\frac{1}{1-\rho}} \pi_t^{\frac{\rho}{1-\rho}} + 1}$$

or with $\omega_t = \pi_t b / \left[a\left(1-\alpha\right)\kappa_t^\alpha\right]$

$$\frac{\alpha}{1-\alpha} \frac{\gamma}{\frac{1-\gamma}{1-\alpha}\frac{1}{\omega_t} - \gamma} > \frac{1}{\left(\frac{\theta}{1-\theta}\right)^{\frac{1}{1-\rho}} \pi_t^{\frac{\rho}{1-\rho}} + 1}$$

Since $\omega_t > 1$ and $\pi_t > 1$ this condition is satisfied whenever

$$\alpha \frac{\gamma}{1-\gamma-(1-\alpha)\gamma} > \frac{1}{\left(\frac{\theta}{1-\theta}\right)^{\frac{1}{1-\rho}} + 1}$$

or $\left(\theta/(1-\theta)\right)^{\frac{1}{1-\rho}} \geq \left(1-2\gamma\right)/\left(\alpha\gamma\right)$ holds, proving the statement (iii).

(iv) Notice with Proposition 2 (i) that $zn_t^* < 1$ implies $k_{t+1}^*/k_{t+1}^{*,A} = p_{1,t}(\kappa_t^*)^\alpha/(p_{1,t}^{*,A}(\kappa_t^{*,A})^\alpha)$. If $zn_t^* = 1$, instead, $k_{t+1}^*/k_{t+1}^{*,A} = p_{1,t}\left((1-\alpha)a\kappa_t^* + b\right)/(p_{1,t}^{*,A}((1-\alpha)a\kappa_t^{*,A}+b))$. Now, inequality (37) and expression (40) for the price $p_{1,t}^{(*,A)}$ imply $p_{1,t}/p_{1,t}^{*,A} \leq 1$. Further, by $m_t^{*,A} \leq m_t^*$ we have $\kappa_t^{*,A} \geq \kappa_t^*$ and thus

$$k_{t+1}^*/k_{t+1}^{*,A} \leq \left(\kappa_t^*/\kappa_t^{*,A}\right)^\alpha$$

Similarly, we compute for $zn_t < 1$ that $k_{t+1}/k_{t+1}^A = p_{1,t}\kappa_t^\alpha/(p_{1,t}^A(\kappa_t^A)^\alpha)$ while for $zn_t = 1$ $k_{t+1}/k_{t+1}^A = p_{1,t}\left((1-\alpha)a\kappa_t^\alpha + b\right)/(p_{1,t}^A((1-\alpha)a(\kappa_t^A)^\alpha + b))$ holds. By (37) and expression (40) we have $p_{1,t}/p_{1,t}^A \geq 1$. Further, by $m_t^A \geq m_t$ we have $\kappa_t^A \geq \kappa_t$ and thus

$$k_{t+1}/k_{t+1}^A \geq \left(\kappa_t/\kappa_t^A\right)^\alpha$$

Combining both inequalities leads to

$$\frac{k_{t+1}^*/k_{t+1}^{*,A}}{k_{t+1}/k_{t+1}^A} \leq \left(\frac{\kappa_t^*/\kappa_t^{*,A}}{\kappa_t/\kappa_t^A}\right)^\alpha = \left(\frac{m_t^{*,A}/m_t^*}{m_t^A/m_t}\right)^\alpha$$

Using again $m_t^{*,A} \leq m_t^*$ and $m_t^A \geq m_t$ shows that the expression on the right falls weakly short of unitiy, which proves the statement. ■

Table A-1: Explanatory Power of Distance on Female Labor Force Participation

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

NOTE.-Robust standard errors adjusted for heteroscedasticity are reported in parentheses. In all regressions the variable Female Labor Force Participation 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 before NAFTA period is 1960–1970 and the during NAFTA period is 1990–2000. Lagged levels are 1950 and 1980, respectively. For the before 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 during NAFTA period regressions to the same 42 states does not affect neither the magnitudes of coefficients nor its significance. See the note to Table 1 for additional sample details and variables definition.

Table A-2: The effect of U.S. trade with Mexico on U.S. Females/Males Labor Force Participation

Dependent Variable	FEMALE				MALE			
	Hours worked		Employment		Hours worked		Employment	
State Weight		+		+		+		+
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Trade with Mexico	−0.72** (0.27)	−0.65*** (0.17)	−0.02** (0.01)	−0.02*** (0.01)	0.60 (0.38)	0.39** (0.17)	0.01 (0.01)	0.01 (0.00)
LFP in 1990/91	−0.25*** (0.08)	−0.42*** (0.07)	−0.29*** (0.08)	−0.39*** (0.08)	−0.08 (0.13)	−0.24** (0.09)	0.11 (0.11)	0.01 (0.09)
	First-Stage Coefficients (Dependent Variable: Δ Trade)							
Distance	−2.06*** (0.56)	−4.79*** (0.68)	−2.06*** (0.57)	−4.74*** (0.67)	−2.12*** (0.56)	−4.56*** (0.71)	−2.10*** (0.56)	−4.60*** (0.71)
	First-Stage Coefficients (Dependent Variable: LFP in 1990/91)							
LFP in 1980/81	0.93*** (0.11)	0.93*** (0.12)	0.92*** (0.09)	0.90*** (0.10)	0.67*** (0.07)	0.79*** (0.08)	0.74*** (0.07)	0.82*** (0.07)
Number of obs	51	51	51	51	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. The independent variables are instrumented by distance and the according Labor Force Participation shares in 1980/81. Regressions described in column 2, 4, 6 and 8 are weighted by state population size. See the note to Table 1 for additional sample details and variables definition.

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