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Comparative Advantage, International Trade, and Fertility

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Abstract

We analyze theoretically and empirically the impact of comparative advantage in international trade on fertility. We build a model in which industries differ in the extent to which they use female relative to male labor, and countries are characterized by Ricardian comparative advantage in either female- or male-intensive goods. The main prediction of the model is that countries with comparative advantage in female-intensive goods are characterized by lower fertility. This is because female wages, and therefore the opportunity cost of child-rearing are higher in those countries. We demonstrate empirically that countries with comparative advantage in industries employing primarily women exhibit lower fertility. We use a geography-based instrument for trade patterns to isolate the causal effect of comparative advantage on fertility.

Keywords: Fertility, trade integration, comparative advantage, factor endowments.

JEL Codes: F16, J13, O11.

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1 Introduction

Attempts to understand population growth and the determinants of fertility date as far back as Thomas Malthus. Postulating that fertility decisions are potentially influenced by prevailing wage rates (Becker, 1960), choice over fertility has been incorporated into growth models with the objective of understanding the joint behavior of population and economic development throughout history (see e.g. Barro and Becker 1989; Becker et al. 1990; Kremer 1993; Galor and Weil 1996, 2000; Greenwood and Seshadri 2002; Doepke 2004; Doepke et al. 2007; Jones and Tertilt 2008). The large majority of existing analyses examine individual countries in a closed-economy setting. However, in an era of ever-increasing integration of world markets, the role of globalization in determining fertility can no longer be ignored. To fill this knowledge gap, this paper studies both theoretically and empirically the impact of comparative advantage in international trade on fertility outcomes.

Our conceptual framework is based on three assumptions. First, goods differ in the intensity of female labor: some industries employ primarily women, others primarily men. This assumption is standard in theories of gender and the labor market (Galor and Weil, 1996; Black and Juhn, 2000; Qian, 2008; Black and Spitz-Oener, 2010; Pitt et al., 2010; Alesina et al., 2011; Rendall, 2010), and as we show below finds ample empirical support in the data. In the rest of the paper, we refer to goods that employ primarily (fe)male labor as the (fe)male-intensive goods. Second, women bear a disproportionate burden of raising children. That is, a child reduces a woman's labor market supply more than a man's. This assumption is also well-accepted (Becker, 1981, 1985; Galor and Weil, 2000), and is consistent with a great deal of empirical evidence (see, e.g., Angrist and Evans, 1998; Guryan et al., 2008). Finally, differences in technologies and resource endowments imply that some countries have a comparative advantage in the female-intensive goods, and others in the male-intensive goods. Our paper is the first to both provide empirical evidence that countries indeed differ in the gender composition of their comparative advantage, and to explore the impact of comparative advantage in international trade on fertility in a broad sample of countries.

The main theoretical result is that countries with comparative advantage in female-intensive goods will exhibit lower fertility. The intuition is that, all else equal, women's wages are higher in countries with a comparative advantage in female-intensive industries. This increases the opportunity cost of children, thereby lowering fertility. We then provide empirical evidence for the main prediction of the model using industry-level export data for 61 manufacturing sectors in 145 developed and developing countries over 5 decades. We use sector-level data on the share of female workers in total employment to classify sectors as female- and male- intensive. The variation across sectors in the share of female workers is substantial: it ranges from 8-9 percent in industries such as heavy machinery to 60-70 percent in some types of textiles and apparel. We then combine this industry-level information with data on countries' export shares to construct, for each country and time period, a measure of its *female-labor needs of exports* that captures the degree to which a country's comparative advantage is in female-labor intensive sectors. We use this measure to test the main prediction of the model: fertility is lower in countries with a comparative advantage in female-labor intensive sectors. The key aspect of the empirical strategy is how it deals with the reverse causality problem. After all, it could be that countries where fertility is lower for other reasons export more in female-intensive sectors. To address this issue, we follow Do and Levchenko (2007) and di Giovanni and Levchenko (2009) and construct an instrument for each country's trade pattern based on geographical characteristics and a gravity-like specification.

The intuition for the instrumental variables strategy is as follows. Exogenous geographical characteristics such as bilateral distance or common border have long been known to affect bilateral trade flows. The influential insight of Frankel and Romer (1999) is that those exogenous characteristics and the strong explanatory power of the gravity relationship can be used to build an instrument for the overall trade openness at the country level. Do and Levchenko (2007) and di Giovanni and Levchenko (2009)'s point of departure is that the gravity coefficients on the same exogenous geographical characteristics such as distance also vary across industries – a feature of the data long known in the international trade literature, and attributable to sectoral characteristics such as the elasticity of substitution between varieties, the value-to-weight ratio, or the importance of timeliness of delivery. This variation in industries' sensitivity to the common geographical variables allows us to construct an instrument for trade *patterns* rather than the overall trade *volumes*. The details for the construction of the instrument are described in Appendix C, and the identification strategy is justified at length in Do and Levchenko (2007). As an alternative approach, we supplement the cross-sectional 2SLS evidence with panel estimates that include country and time fixed effects.

Both cross-sectional and panel results support the main empirical prediction of the model: countries with a higher female intensity of exports exhibit lower fertility. The effect is robust to the inclusion of a large number of other covariates of fertility, and is economically significant. Moving from the 25th to the 75th percentile in the distribution of the female-labor needs of exports lowers fertility by as much as 20 percent, or about 0.36 standard deviations of fertility across countries.

Our paper contributes to the (still sparse) literature that examines fertility in the context of international integration. Schultz (1985) shows that the large changes in world agricultural prices and the gender division of labor in agriculture affected fertility in 19th-century Sweden. Galor and Mountford (2009) develop a model in which trade opening leads to higher investments in skills in the initially more developed countries, but to faster population growth in the initially less developed countries. They then provide empirical evidence that higher trade volumes are associated with less fertility and more education in the OECD countries, while the opposite holds for the non-OECD countries. Our theory and empirical results explore a complementary and distinct economic mechanism. While Galor and Mountford (2009) do not differentiate individuals by gender, or industries by gender-intensity, these distinctions are at the heart of our analysis. In addition, our empirical results reveal the impact of trade patterns, rather than overall trade volumes, on fertility. Sauré and Zoabi (2011a,b) study the impact of trade on the female labor share, wage gap, and fertility in a factor proportions framework featuring complementarity between capital and female labor. Our main mechanism is based on Ricardian productivity differences, and does not rely on a differential impact of capital accumulation on female and male labor. Rees and Riezman (2011) argue that when globalization improves work opportunities for women, fertility will fall. In contrast to Rees and Riezman (2011), our model examines international trade as opposed to foreign direct investment and links fertility outcomes explicitly to comparative advantage. In addition, we provide extensive empirical evidence to support our hypothesis. Finally, our paper also relates to the small but growing literature on the impact of globalization on gender outcomes more broadly (Black and Brainerd, 2004; Oostendorp, 2009; Aguayo-Tellez et al., 2010; Ural Marchand et al., 2011). These papers typically focus on gender discrimination outcomes, such as the female-male wage gap, and emphasize different channels linking gender outcomes to globalization.

The rest of the paper is organized as follows. Section 2 presents a simple two-country two-sector model of comparative advantage in trade and endogenous fertility. Section 3 lays out our empirical strategy to test the predictions of the model. Section 4 describes the data, while section 5 presents estimation results. Section 6 concludes. All the proofs are collected in Appendix A.

2 Theoretical Framework

2.1 The Environment

Consider an economy comprised of two countries indexed by $c \in \{X, Y\}$, and two sectors indexed by $i = \{F, M\}$. The representative household in c values consumption C_F^c and C_M^c of the two goods, as well as the number of children N^c it has according to some utility function

$u\left(C_F^c, C_M^c, N^c\right)$. For analytical simplicity, we assume that $u(.)$ takes the form

$$u\left(C_F^c, C_M^c, N^c\right) = \left(C_F^c\right)^{\eta}\left(C_M^c\right)^{1-\eta} + v\left(N^c\right),$$

i.e. utility is additively separable in the consumption bundle and the number of children and $v(.)$ is increasing and concave.[1] To guarantee interior solutions, we further assume that $\lim_{N\to 0} v'(N) = +\infty$.

We adopt the simplest form of the gender division of labor, and assume that production in sector F only requires female labor and capital, while sector M only requires male labor and capital. Technology is therefore given by

$$Y_i^c\left(K_i, L_i\right) = i^c K_i^{\alpha} L_i^{1-\alpha},$$

where L_i is the amount of female labor ($i = F$) and male labor ($i = M$) employed in production, K_i is the amount of capital employed in sector i, and $\{i^c\}_{i\in\{M,F\}}$ are total factor productivities in the two sectors in country c. Formally, this is the specific-factors model of production and trade (Jones, 1971; Mussa, 1974), in which female and male labor are specific to sectors F and M respectively, while K can move between the sectors. Thus, we take the arguably simplistic view that men supply "brawn-only" labor, while women supply "brain-only" labor, and men and women are not substitutes for each other in production within each individual sector. Of course, there is still substitution between male and female labor in the economy as a whole, since goods F and M are substitutable in consumption.

The key to our results is the assumption that countries differ in their relative productivities F^c/M^c. For convenience, we normalize

$$\left(F^c\right)^{\eta}\left(M^c\right)^{1-\eta} = 1 \quad (1)$$

in both countries. Since the impact of relative country sizes is not the focus of our analysis, and the aggregate gender imbalances in the population tend to be small, we set the country endowments of male and female labor and capital to be $\bar{L}_M^c = \bar{L}_F^c = 1$ and $\bar{K}^c = 1$ for $c \in \{X, Y\}$. Capital can move freely between sectors, and the market clearing condition for capital is $K_F^c + K_M^c = 1$.

Men supply labor to the goods production sector only, and hence supply it inelastically: $L_M^c = 1$. On the other hand, home production requires female labor, and women split their time between goods production and child-rearing. We assume that spending λ^c units of female labor in home production allows raising $N^c = N\left(\lambda^c\right)$ children, where $N(.)$ is assumed

[1] Appendix B analyzes a more general form of preferences over consumption goods and children.

to be continuously differentiable and increasing and we normalize $N(0) = 0$. Thus, female market labor force participation is $L_F^c = 1 - \lambda^c$.

All goods and factor markets are competitive. International trade is costless, while capital and labor cannot move across countries. In country c, capital earns return r^c and female and male workers are paid wages w_F^c and w_M^c, respectively. Let the price of goods $i \in \{M, F\}$ be denoted by p_i, and set the price of the goods consumption basket to be numeraire:[2]

$$p_F^{\eta} p_M^{1-\eta} = 1. \tag{2}$$

A **competitive equilibrium** in this economy is a set of prices $\{p_F, p_M, r^c, w_F^c, w_M^c\}_{c \in \{X,Y\}}$, factor allocations $\{K_M^c\}_{c \in \{X,Y\}}$ and female (formal) labor force participation rates $\{L_F^c\}_{c \in \{X,Y\}}$, such that (i) consumers maximize utility; (ii) firms maximize profits; (iii) all goods and factor markets clear. In the rest of the section, we will solve for the equilibrium in two steps. We first consider the global goods production and consumption allocations for a given female labor force participation decision $L_F^c = 1 - \lambda^c$ (or, equivalently, fertility decision N^c). We then endogenize households' decisions over fertility.

2.2 Production and Trade Equilibrium

Suppose that the female labor supply is $L_F^c = 1 - \lambda^c$, where we recall that λ^c is the amount of time a woman spends at home raising her children. To characterize the production and trade equilibrium, we set up (i) the firms' and consumers' first order conditions, and (ii) market clearing conditions. It will be convenient to express all the equilibrium outcomes of the economy (prices and quantities) as functions of $f^c \equiv \frac{1}{K_M^c}$, which is a measure of the size of the female-labor intensive sector.

Firms' Optimization

In each of the two sectors, firms rent capital and hire labor to maximize profits. In other words, the sector $i \in \{M, F\}$ firms solve the following optimization problem:

$$\max_{K,L} p_i i^c K^{\alpha} L^{1-\alpha} - r^c K - w_i^c L.$$

The necessary and sufficient first-order conditions with respect to K_i^c yield the following expression for the return to capital: $\frac{r^c}{p_i} = \alpha i^c \left(\frac{L_i^c}{K_i^c}\right)^{1-\alpha}$. Equalizing the returns to capital across sectors and assuming that labor markets clear pins down relative prices of the two

[2] Due to the assumption that trade is costless, goods prices are the same in the two countries and thus carry no country superscripts.

goods: $\frac{p_F}{p_M} = \frac{M^c}{F^c}\left(\frac{f^c-1}{1-\lambda^c}\right)^{1-\alpha}$. Since the adopted numeraire is the consumption bundle, i.e. (2) holds, prices are equal to

$$\begin{cases} p_F &= \left[\frac{M^c}{F^c}\left(\frac{f^c-1}{1-\lambda^c}\right)^{1-\alpha}\right]^{1-\eta} \\ p_M &= \left[\frac{F^c}{M^c}\left(\frac{1-\lambda^c}{f^c-1}\right)^{1-\alpha}\right]^{\eta} \end{cases}, \tag{3}$$

which yields the following expression for the return to capital:

$$r^c \;=\; \alpha\left[f^c\left(\frac{1-\lambda^c}{f^c-1}\right)^{\eta}\right]^{1-\alpha}. \tag{4}$$

Finally, the necessary and sufficient first-order conditions with respect to L_i^c yield $\frac{w_i^c}{p_i} = (1-\alpha)\, i^c\left(\frac{K_i^c}{L_i^c}\right)^{\alpha}$ so that equilibrium wages of women and men are

$$w_F^c = (1-\alpha)\left(\frac{1}{f^c}\right)^{\alpha}\left(\frac{f^c-1}{1-\lambda^c}\right)^{1-\eta(1-\alpha)} \tag{5}$$

and

$$w_M^c = (1-\alpha)\left(\frac{1}{f^c}\right)^{\alpha}\left(\frac{f^c-1}{1-\lambda^c}\right)^{-\eta(1-\alpha)}. \tag{6}$$

Consumers' Optimization

The Cobb-Douglas specification of the consumption bundle implies constant expenditure shares on the two goods, i.e. $p_F C_F^c = \eta E^c$ and $p_M C_M^c = (1-\eta)\, E^c$, where expenditure is equal to aggregate income, derived from wages paid to labor and rental of capital:

$$E^c = r^c + w_F^c\,(1-\lambda^c) + w_M^c.$$

Therefore, aggregate consumption is split as follows:

$$\frac{p_F C_F^c}{\eta} = \frac{p_M C_M^c}{1-\eta} = r^c + w_F^c\,(1-\lambda^c) + w_M^c. \tag{7}$$

Market Clearing Conditions

In sector F, world consumption and production equalize, so that

$$\sum_c p_F F^c\,(1-K_M^c)^{\alpha}\,(1-\lambda^c)^{1-\alpha} \;=\; \eta\left[\sum_c r^c + (1-\lambda^c)\, w_F^c + w_M^c\right],$$

which simplifies to

$$\sum_c M^c \left(\frac{1}{f^c}\right)^\alpha [1-(1-\eta) f^c] = 0. \tag{8}$$

Since goods prices are the same everywhere, equalizing the right-hand sides of equation (3) in the two countries for sector F leads to the following condition:

$$\frac{M^c}{F^c}\left(\frac{f^c-1}{1-\lambda^c}\right)^{1-\alpha} = \frac{M^{-c}}{F^{-c}}\left(\frac{f^{-c}-1}{1-\lambda^{-c}}\right)^{1-\alpha}, \tag{9}$$

where the notation "$-c$" denotes "not country c."

Characterization of Production Equilibrium

We define:

$$\gamma^c = \left(\frac{F^c}{M^c}\frac{M^{-c}}{F^{-c}}\right)^{\frac{1}{1-\alpha}}$$

and

$$\rho^c = \gamma^c \frac{1-\lambda^c}{1-\lambda^{-c}}.$$

A value $\rho^c > 1$ indicates that country c has a comparative advantage in the female-labor intensive good F. The comparative advantage can be decomposed into a *technological* or Ricardian component γ^c and an *occupational* or "factor-proportions" component $\frac{1-\lambda^c}{1-\lambda^{-c}}$, which can exacerbate or attenuate technological differences. We rewrite the two equations (8) and (9) as a system of two equations with two unknowns $\{f^c, f^{-c}\}$ given exogenous model parameters and $\{\lambda^c, \lambda^{-c}\}$:

$$(f^c)^{-\alpha}[1-(1-\eta) f^c] + (\gamma^c)^{\eta(1-\alpha)} \left(f^{-c}\right)^{-\alpha}\left[1-(1-\eta) f^{-c}\right] = 0 \tag{10}$$

$$\rho^c \frac{f^{-c}-1}{f^c-1} = 1 \tag{11}$$

Equation (10) implicitly defines a downward-sloping "goods market-clearing curve" in the space (f^{-c}, f^c) and is just a rearrangement of equation (8), keeping in mind that normalization (1) implies that $\frac{M^{-c}}{M^c} = \left(\frac{F^c M^{-c}}{M^c F^{-c}}\right)^\eta = (\gamma^c)^{\eta(1-\alpha)}$. Since goods produced by the two countries are perfect substitutes, market clearing implies a negative relationship between the size f^c of the F-sector in country c and its size f^{-c} in country $-c$. On the other hand, the upward-sloping "factor market-clearing curve" in the space (f^{-c}, f^c), defined by (11), implies that F-sectors have to be of comparable size in the two countries (i.e. the larger sector F gets in country c, the larger it needs to be in country $-c$ as well), otherwise the return to capital will diverge across the F- and M-sectors in each country. Thus, allocations of capital between two sectors in the two countries $\left\{f^X, f^Y\right\}$ are uniquely determined by the system of two equations (10) and (11).

In summary, we have the following result:

Proposition 1: Production and Trade Equilibrium Consider the endowment structure $\left\{\bar{K}^c, \bar{L}_M^c, L_F^c\right\}_{c\in\{X,Y\}} = \{1, 1, 1-\lambda^c\}_{c\in\{X,Y\}}$. The unique production and consumption equilibrium is characterized by the vector of prices $\{p_F, p_M, r^c, w_F^c, w_M^c\}_{c\in\{X,Y\}}$ in (3) to (6), and factor allocations $\left\{f^X, f^Y\right\}$ that solve (10) and (11).■

The proof of Proposition 1 establishes existence of an intersection of the two "factor market-clearing" and "goods market-clearing" curves, which is therefore unique since the two curves have opposite slopes. The analysis above is carried out under an exogenously fixed fertility rate or, equivalently, an exogenously fixed level of female labor force participation. We now turn to endogenizing households occupational choices and fertility decisions.

2.3 Occupational Choice and Fertility Decisions

To pin down equilibrium λ^c, we proceed in two steps. First, for a given λ^{-c}, w_F^c and λ^c are endogenously determined by labor supply and demand. Thus, we must ensure that labor supply is upward-sloping and the female labor market equilibrium is well defined. Second, female labor supply decision λ^{-c} of the other country affects the labor market equilibrium in c by shifting female labor demand in c. We therefore must find a fixed point in $\{\lambda^c, \lambda^{-c}\}$ such that the female labor markets are in equilibrium in both countries simultaneously.

Female Labor Supply

Taking λ^{-c} as given and anticipating the production equilibrium prices and quantities, households make fertility decisions accordingly. Namely, they take prices as given and choose the share of female labor spent at home λ^c to maximize their indirect utility:

$$V^c(\lambda) = r^c + w_F^c(1-\lambda) + w_M^c + v\left[N(\lambda)\right].$$

When the solution is interior, the first-order condition for the representative household's fertility decision is given by

$$w_F^c = N'(\lambda^c)\, v'\left[N(\lambda^c)\right]. \tag{12}$$

Lemma 1: Fertility Decision Consider the following assumption: for every $\lambda \in [0,1]$,

$$N"(\lambda)\, v'[N(\lambda)] + [N'(\lambda)]^2\, v"[N(\lambda)] \leq 0. \tag{13}$$

Then, first-order condition (12) is sufficient if and only if (13) holds.■

The left-hand side of (13) is the second derivative of $v[N(\lambda)]$, and thus the inequality amounts to the assumption that $v[N(\lambda)]$ is concave. Since $v(.)$ is assumed to be concave, condition (13) trivially holds if $N(.)$ is also concave, i.e. the production of children exhibits non-increasing returns. However, while sufficient, concavity of $N(.)$ is not necessary. For the solution to be determined by (12), it is only necessary to assume that the composite function $v[N(\lambda)]$ is concave – a weaker condition. Intuitively, $v[N(\lambda)]$ aggregates preference for and production technology of children. The restriction (13) requires that marginal utility of having an additional child decreases faster than the reduction – if any – in the marginal cost of producing this additional child.

The female labor market supply curve is therefore defined as

$$\begin{cases} w_F^c = N'(\lambda^c)\, v'[N(\lambda^c)] & \text{if } \lambda^c < 1 \\ w_F^c \leq N'(1)\, v'[N(1)] & \text{if } \lambda^c = 1 \end{cases}. \tag{14}$$

Under assumption (13), female formal labor market supply is upward-sloping: a rise in women's wages increases female market labor supply and hence reduces fertility. In general, an increase in women's wage will have both income and substitution effects. Higher female wages represent a higher opportunity cost of having children, and thus the substitution effect implies that a rise in women's wages increases female market labor supply and hence reduces fertility. However, higher female wages can also have an income effect: since children are a normal good, all else equal higher female wages can also lead to more children, and thus *lower* formal labor supply. The utility function adopted in the main text, which is linear in income and additively separable in consumption and fertility, allows us to sidestep the income effect and thus let the female labor supply curve be driven by the substitution effect. The upward-sloping female labor supply curve and the associated negative relationship between female wages and fertility are in line with a large body of both theoretical and empirical literature, going back to Becker (1965), Willis (1973), and Becker (1981). Appendix B considers a more general utility function and derives conditions for the income effect to be sufficiently small for the female market labor supply curve to be well-defined and upward sloping.

Female Labor Demand

For a given set of parameters $\{F^X, M^X, F^Y, M^Y, \lambda^{-c}\}$, equation (5) defines a downward-sloping female market labor demand curve. To see this, we rewrite labor demand using (11):

$$w_F^c = (1-\alpha)\left(\frac{1}{f^c}\right)^{\alpha}\left(\gamma^c \frac{f^{-c}-1}{1-\lambda^{-c}}\right)^{1-\eta(1-\alpha)}. \tag{15}$$

Thus, for a given female labor force supply $1-\lambda^{-c}$ in country $-c$, w_F^c decreases with f^c and increases with f^{-c}. To sign the slope of the female labor demand curve, we first establish the following result:

Lemma 2: Comparative statics If comparative advantage of country $c \in \{X, Y\}$ in the female-labor intensive sector becomes stronger (ρ^c increases), then country c has a larger female-labor intensive sector: $\frac{df^c}{d\rho^c}(\rho^c) > 0.$■

Thus, an increase in female labor supply in country c increases c's comparative advantage in the female-labor intensive good (the factor-proportions effect). This will increase f^c, the size of the F-sector in country c and exert a downward pressure on female wages. By the same token, country $-c's$ comparative advantage in the female-labor intensive good is reduced, decreasing f^{-c}, the size of the F-sector in that country, which in turn will put additional downward pressure on female wages in country c. The female labor demand curve is therefore downward-sloping.

Proposition 2: Labor force participation in partial equilibrium For a given level of the other country's female labor force participation $(1-\lambda^{-c})$, there exists a unique λ^c satisfying both (14) and (15).■

In the proof of Proposition 2, we establish that the female formal market labor supply and demand curves either intersect at the corner, i.e. $\lambda^c = 1$, or in the interior, in which case the labor market equilibrium is characterized by

$$N'(\lambda^c)\, v'[N(\lambda^c)] = (1-\alpha)\left(\frac{1}{f^c}\right)^{\alpha}\left(\frac{f^c-1}{1-\lambda^c}\right)^{1-\eta(1-\alpha)}. \tag{16}$$

Equilibrium Fertility

Lemma 2 and the labor demand equation (15) imply that the female labor demand curve in country c shifts down when female labor supply in country $-c$ goes up. Thus $\lambda^c(\lambda^{-c})$, the equilibrium female labor force participation rate in country c when that rate in country

$-c$ is λ^{-c}, is decreasing; so is $\lambda^{-c}(\lambda^c)$. The following proposition formally establishes that these two "reaction functions" intersect and therefore defines the complete equilibrium of the economy.

Proposition 3: Characterization of the Complete Equilibrium Equations (3) to (6), (11), and (14) define a vector of prices $\{p_F, p_M, r^c, w_F^c, w_M^c\}_{c\in\{X,Y\}}$, factor allocations $\{K_M^c\}_{c\in\{X,Y\}}$ and female labor force participations $\{1-\lambda^c\}_{c\in\{X,Y\}}$ that form the unique equilibrium of the economy.■

Cross-Sectional Comparisons

We now consider (f^c, λ^c) and $(\tilde{f}^c, \tilde{\lambda}^c)$, two equilibrium capital and female labor allocations of the economy when the Ricardian comparative advantage of country c takes values γ^c and $\tilde{\gamma}^c$, respectively. The objective of this section is to compare fertility and the allocation of capital across sectors in these two parameter configurations.

To evaluate at the effect of changes in comparative advantage on the allocation of labor and capital, we take the ratio of female wages in the two countries and use (11) to obtain the following equality:

$$\frac{N'(\lambda^c)\, v'[N(\lambda^c)]}{N'(\lambda^{-c})\, v'[N(\lambda^{-c})]}\left(\frac{f^c}{f^{-c}}\right)^{\alpha} = (\gamma^c)^{1-\eta(1-\alpha)}. \tag{17}$$

Equality (17) implies that if $\gamma^c \geq \tilde{\gamma}^c$ then either $\frac{N'(\lambda^c)v'[N(\lambda^c)]}{N'(\lambda^{-c})v'[N(\lambda^{-c})]} \geq \frac{N'(\tilde{\lambda}^c)v'[N(\tilde{\lambda}^c)]}{N'(\tilde{\lambda}^{-c})v'[N(\tilde{\lambda}^{-c})]}$ or $\frac{f^c}{f^{-c}} \geq \frac{\tilde{f}^c}{\tilde{f}^{-c}}$, or both. In other words, a change in comparative advantage triggers either a change in fertility choices in either or both countries ($\lambda^c \leq \tilde{\lambda}^c$ and/or $\lambda^{-c} \geq \tilde{\lambda}^{-c}$), or a reallocation of capital across sectors in either or both countries ($f^c \geq \tilde{f}^c$ and/or $f^{-c} \leq \tilde{f}^{-c}$). However, since $\gamma^c = 1/\gamma^{-c}$, a stronger comparative advantage in the F-good in country c is associated with a weaker comparative advantage in country $-c$, vice and versa. Therefore, if a change in comparative advantage positively (resp. negatively) affects fertility in country c, it will simultaneously negatively (resp. positively) affect fertility in country $-c$. The same holds for capital allocation. Thus, we can state the following:

$$\gamma^c \geq \tilde{\gamma}^c \Longrightarrow \left(\lambda^c \leq \tilde{\lambda}^c \text{ and } \lambda^{-c} \geq \tilde{\lambda}^{-c}\right) \textbf{ or } \left(f^c \geq \tilde{f}^c \text{ and } f^{-c} \leq \tilde{f}^{-c}\right) \tag{18}$$

Finally, to see that *both* labor and capital respond to an exogenous change in comparative advantage, we note that the right-hand side of (16) is increasing in f^c, while the left-hand side is decreasing in λ^c. The following equivalence therefore holds:

$$f^c \geq \tilde{f}^c \Longleftrightarrow \lambda^c \leq \tilde{\lambda}^c. \tag{19}$$

That is, a higher inflow of capital in the F-sector is associated with higher female labor force participation and hence lower fertility in equilibrium.

The last term in (18) is therefore redundant and we can simply write

$$\gamma^c \geq \tilde{\gamma}^c \Longrightarrow \left(\lambda^c \leq \tilde{\lambda}^c \text{ and } \lambda^{-c} \geq \tilde{\lambda}^{-c}\right). \tag{20}$$

The above discussion leads to the following proposition:

Proposition 4: Cross-Sectional Comparison If country c has a Ricardian comparative advantage in the female-labor intensive sector ($\frac{F^c}{M^c} > \frac{F^{-c}}{M^{-c}}$), it will exhibit lower equilibrium fertility: $N^c < N^{-c}$.■

Proposition 4 gives the main theoretical prediction of the model, and one that will be tested empirically: Ricardian comparative advantage gets reinforced by a factor-proportions component when agents choose fertility and labor force participation rates. The intuition for this result is as follows. Female wages will be higher in the country with the comparative advantage in the female-intensive sector, both because of higher relative productivity and because capital will flow to the comparative advantage sector. Since a higher female wage increases the opportunity cost of childbearing in terms of goods consumption, equilibrium childbearing drops.

The theoretical exposition above makes clear what the measurement and identification challenges for the empirical work are. First, in order to test for the impact of gender-biased comparative advantage on fertility, we must develop a measure of comparative advantage in (fe)male sectors. Fortunately, the model presents us with a way of doing this: observed trade flows. Countries with a comparative advantage in the female-intensive good will export that good. Our empirical strategy thus starts by building a measure of the female intensity of exports based on observed export specialization. Second, the model shows quite clearly that observed specialization patterns and trade flows are endogenous to fertility: countries with higher technological comparative advantage in the female sector will accentuate that comparative advantage with a higher female labor supply and will thus effectively exhibit relative factor proportions that also favor exports in the female-intensive sectors. Thus, in order to provide evidence for the causal impact of comparative advantage on fertility, we must find an exogenous source of variation in comparative advantage. We describe all parts of our empirical strategy and results below.

3 Empirical Strategy

To test for the impact of comparative advantage on fertility, we must first construct a measure of the degree of female bias in a country's export pattern. We begin by classifying sectors according to their female intensity. Let an industry's female-labor intensity FL_i be measured as the share of female workers in the total employment in sector i. We take this measure as a technologically determined industry characteristic that does not vary across countries. We then construct for each country and time period a measure of the "female-labor needs of exports":

$$FLNX_{ct} = \sum_{i=1}^{I} \omega_{ict}^{X} FL_i, \tag{21}$$

where i indexes sectors, c countries, and t time periods. In this expression, ω_{ict}^{X} is the share of sector c exports in country c's total exports to the rest of the world in time period t. Thus, $FLNX_{ct}$ in effect measures the gender composition of exports in country c. This measure is meant to capture the female bias in each country's comparative advantage. It will be high if a country exports mostly in sectors with a large female share of employment, and vice versa.[3]

Using this variable, we would like to estimate the following equation in the cross-section of countries:

$$N^c = \alpha + \beta FLNX_c + \gamma \mathbf{Z}_c + \varepsilon_c. \tag{22}$$

The left-hand side variable N^c is, as in Section 2, the number of births per woman, and $\mathbf{Z}_c$ is a vector of controls. The main hypothesis is that the effect of comparative advantage in female-intensive sectors $FLNX_c$ on fertility is negative ($\beta < 0$). The potential for reverse causality is immediate here: higher fertility will reduce women's formal labor force participation and therefore could also affect the country's export pattern. To deal with reverse causality, we implement an instrumentation strategy that follows Do and Levchenko (2007), and exploits exogenous geographical characteristics of countries, together with how those exogenous characteristics affect international trade in different industries differentially. The construction of the instrument is described in detail in Appendix C.

We also exploit the time variation in the variables to estimate a panel specification of the

[3] The form of this index is based on Almeida and Wolfenzon (2005) and Do and Levchenko (2007), who build similar indices to capture the external finance needs of production and exports.

type

$$N_t^c = \alpha + \beta FLNX_{ct} + \gamma \mathbf{Z}_{ct} + \delta_c + \delta_t + \varepsilon_{ct}, \tag{23}$$

where country and time fixed effects are denoted by δ_c and δ_t respectively. The advantage of the panel specification is that the use of fixed effects allows us to control for a wide range of time-invariant omitted variables that vary at the country level, and identify the coefficient purely from the time variation in comparative advantage and fertility outcomes *within a country over time.*

The baseline controls include PPP-adjusted per capita income, overall trade openness, and, in the case of cross-sectional regressions, regional dummies. (We also check robustness of the results to a number of additional control variables.) The cross-sectional specifications are estimates on long-run averages for the period 1980-2007. The panel specifications are estimated on non-overlapping 5-year and 10-year averages. As per standard practice, we take multi-year averages in order to sweep out any variation at the business cycle frequency. The panel data span 1962 to 2007 in the best of cases, though not all variables for all countries are available for all time periods.

4 Data Sources and Summary Statistics

The key indicator required for the analysis is the share of female workers in the total employment in each sector, FL_i. This information comes from the UNIDO Industrial Statistics Database (INDSTAT4 2009), which records the total employment and female employment in each manufacturing sector for a large number of countries at the 3-digit ISIC Revision 3 classification (61 distinct sectors), starting in the late 1990s. We compute FL_i as the mean share of female workers in total employment in sector i across the countries for which these data are available and relatively complete. This sample includes 11 countries in each of the developed and developing sub-samples: Austria, Cyprus, Ireland, Italy, Japan, Lithuania, Korea, Malta, New Zealand, Slovak Republic, United Kingdom; and Azerbaijan, Chile, Egypt, India, Indonesia, Jordan, Malaysia, Morocco, Philippines, Thailand, Turkey. Table 1 reports the values of FL_i in our sample of sectors. It is clear that there is wide variation in the share of women in sectoral employment. While the mean is 27 percent, these values range from the high of 71 percent in Wearing Apparel and 62 percent in Knitted and Crocheted Fabrics to the low of 8 or 9 percent in Motor Vehicles, Bodies of Motor Vehicles, Building and Repairing of Ships, and Railway Locomotives.[4] The export shares ω_{ict}^X are calculated

[4]One may be concerned that these values are very different across countries in general, and across developed and developing countries in particular. However, it turns out that the rankings of sectors are remarkably similar across countries. The values of FL_i computed on the OECD and non-OECD samples have a corre-

based on the COMTRADE database, which contains bilateral trade data starting in 1962 in the 4-digit SITC revision 1 and 2 classification. The trade data are aggregated up to the ISIC Revision 3 classification using a concordance developed by the authors.

Table 2 reports some summary statistics for the female labor needs of exports for the OECD and non-OECD country groups. We observe that for the OECD, the measure is relatively stable across decades, with an average of about 0.25. For the non-OECD countries, the female labor needs of exports is higher, between 0.27 and 0.30, and, if anything, rising over time. Notably, the dispersion in $FNLX$ among the non-OECD countries is both much greater than among the OECD, and increasing over time. In the OECD sample, the standard deviation is stable at 0.03-0.04, whereas in the non-OECD sample it rises monotonically from 0.08 to 0.12 between the 1960s and the 2000s.

Tables 3 reports the countries with the highest and lowest $FLNX$ values. Typically, countries with the highest values of female content of exports are those that export mostly textiles and wearing apparel, while countries with the lowest $FLNX$ are natural resource exporters. Equally important for our empirical strategy are changes over time. Tables 4 reports the countries with the largest positive and negative changes in $FLNX$ between the 1960s and today. We can see that relative to the cross-sectional variation, the time variation is also considerable.

Data on fertility are sourced from the World Bank's World Development Indicators. The baseline controls – PPP-adjusted per capita income and overall trade openness – come from the Penn World Tables 6.3 (Heston et al., 2002). Table 2 presents the summary statistics for fertility (number of births per women) in each decade and separately for OECD and non-OECD countries. There is considerable variation in fertility across countries: while the median fertility after 1980 is 3.3 births per woman in our sample of countries, the standard deviation is 1.8, and the 10th-90th percent range spans from 1.4 to 6.3. The table highlights the pronounced cross-sectional differences between high- and low-income countries, as well as the secular reductions in fertility over time in both groups of countries. Our final dataset contains country-level variables on up to 145 countries.

lation of 0.89. Pooling all the countries together, the first principal component explains 77 percent of the cross-sectoral variation across countries, suggesting that rankings are very similar. We also experimented with taking alternative averages: medians instead of means across countries; and dropping outlier values of female shares in individual sectors. The results were very similar. Another concern is that FL_i is measured based on data from the last 10-15 years, whereas our estimation sample goes back several decades. We are not aware of similar data for earlier periods. Our measure of FL_i can be combined with data for earlier time periods as long as there are no "gender-intensity revesals" over time, that is, the ranking of industries by female intensity is stable.

5 Empirical Results

5.1 Cross-sectional results

Table 5 reports the results of estimating the cross-sectional specification in equation (22). Both left-hand side and the right-hand side variables are in natural logs. All of the specifications control for income per capita and overall openness. Column 1 presents the OLS results. There is a pronounced negative relationship between the female-labor need of exports and fertility, significant at the one percent level. By contrast, the coefficient on overall trade openness is zero to the second decimal point and not significant. As is well known, income per capita is significantly negatively correlated with fertility. These three variables absorb a great deal of variation in fertility across countries: the R^2 in this regression is 0.63. Column 2 repeats the OLS exercise but including the regional dummies.[5] The R^2 increases to 0.86, but the female labor need of exports remains equally significant.

Column 3 implements the 2SLS procedure. The bottom panel displays the results of the first stage. As expected, the instrument is highly significant with a t-statistic of 9.4, and the F-statistic for the excluded instrument of 43 is comfortably within the range that allows us to conclude that the instrument is strong (Stock and Yogo, 2005). In the second stage, the main variable of interest, $FNLX$, is statistically significant at the one percent level, with a coefficient that is about one-third larger in absolute value than the OLS coefficient. Column 4 repeats the 2SLS exercise adding regional dummies. The second-stage coefficient of interest both increases in absolute value and becomes more statistically significant.

The OLS and 2SLS results described above constitute the main cross-sectional finding of the paper. Countries that have a comparative advantage in the female-intensive sectors exhibit lower fertility. The estimates are economically significant. Taking the coefficient in column 4 as our preferred estimate, a 10 percent change in $FNLX$ leads to a 4.7 percent lower fertility rate. In absolute terms, this implies that moving from the 25th to the 75th percentile in the distribution of the female content of exports lowers fertility by as much as 20 percent, or about 0.36 standard deviations of average fertility across countries. Applied to the median of 3.3 births per woman in this sample of countries, the movement from the 25th to the 75th percentile in $FLNX$ implies a reduction of 0.64 births per woman.

[5]The regional dummies correspond to the official World Bank region definitions: East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa.

5.2 Robustness

We now check the robustness of the cross-sectional result in a number of ways. The first set of checks is on how the instrument construction treats zero trade observations. As detailed in Appendix C, the baseline instrument estimates the standard log-linear gravity specification that omits zeros in the trade matrix, and predicts trade only for those values in which observed trade is positive. We address the issue of zeros in two ways. The first is to predict trade values for the observations in which actual trade is zero based on the same log-linear regression. The second is to instead estimate a Poisson pseudo-maximum likelihood model on the levels of trade values, as suggested by Santos Silva and Tenreyro (2006). In this exercise, the zero trade observations are included in the estimation sample. The results of using those two alternative instruments are presented in columns 5 and 6 of Table 5. It is clear that very little is changed. The instruments continue to be strong, and the second-stage coefficients of interest are similar in magnitude and significant at the one percent level. We conclude from this exercise that the way zeros are treated in the construction of the instrument does not affect the main results.

Table 6 performs a number of additional checks. All columns report the 2SLS results controlling for openness, income, and regional dummies. Column 1 drops outliers: the top 5 and bottom 5 countries in the distribution of $FNLX$. Column 2 drops the OECD countries, to make sure that our results are not driven simply by the distinction between high-income countries and everyone else.[6] Column 3 drops the Middle East and North Africa region, and column 4 drops Sub-Saharan Africa. It is clear that the results are fully robust to dropping outliers and these important country groups. The coefficients are similar to the baseline and the significance is at one percent throughout. Column 5 controls for female schooling, to account for the possible relationship between education and fertility. Female schooling is measured as the average number of years of schooling in the female population over 25, and is sourced from Barro and Lee (2000). While higher female schooling is indeed associated with lower fertility, the coefficient on $FNLX$ changes little and continues to be significant at the one percent level. Column 5 controls for the prevalence of child labor, since fertility is expected to be higher when children can contribute income to the household. Child labor is measured as the percentage of population aged 10-14 that is working, and comes from Edmonds and Pavcnik (2006). While the prevalence of child labor is indeed positively associated with fertility, the main coefficient of interest remains robust. Next,

[6] OECD countries in the sample are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. We thus exclude the newer members of the OECD, such as Korea and Mexico.

column 7 controls for income inequality, using the Gini coefficent from the World Bank's World Development Indicators. Higher inequality is associated with higher fertility, but once again the main result is robust. Finally, column 8 controls for the extent of democracy, using the Polity2 index from the Polity IV database. The extent of democracy is not significantly associated with fertility, and $FNLX$ is still significant at the one percent level.

Finally, one may be concerned about how the female intensity of industries FL_i is calculated. The results above use the UNIDO database to construct FL_i. The advantage of this approach is that UNIDO covers a large set of countries, and thus will give a more representative picture of the employment of female workers in the world. However, one problem with using the UNIDO data is that it only contains information on manufacturing. To the extent that some countries export significant amounts of agricultural and mining raw materials, this may introduce measurement error into $FNLX$. To address this coverage issue, we construct FL_i based on data for a single country – the U.S. – using the Labor Force Statistics database of the U.S. Bureau of Labor Statistics (BLS). Based on data from the Current Population Survey, the BLS publishes "Women in the Labor Force: A Databook" on an annual basis since 2005. It contains information on total employment and the female share of employment in each industry covered by the Census. The data are available at the 4-digit U.S. Census 2007 classification (262 distinct sectors, including both manufacturing and non-manufacturing). In order to construct the share of female workers in total sectoral employment FL_i, we take the mean of this value across the years for which the data on the female share of employment are available (2004-2009). After dropping non-tradeables, the sector sample includes 78 manufacturing and 15 non-manufacturing sectors. Appendix Table A1 reports the values of FL_i for the top and bottom 5 sectors according to U.S. data. These sectors are similar to what we find in our baseline measure: the least female-intensive sectors tend to be in heavy machinery, while the most female-intensive sectors in textiles and apparel. Appendix Table A2 presents the basic summary statistics of the U.S.-based FL_i measure, breaking up the manufacturing and the non-manufacturing sectors.

While the U.S.-based alternative FL_i measure has the advantage of extending the set of sectors to agriculture and mining, it has two important drawbacks. First, the data are compiled based on individual-level surveys rather than firm- or plant-level data, and thus relies on workers self-reporting their industry of occupation. If the number of individuals in the survey who report working in a particular sector is small, or if workers make mistakes in reporting their industry of employment, the data will be measured with error. And second, the U.S. is only one, very special country, and thus its values of FL_i may not be representative of the average country's experience.[7] Both of these considerations will raise the amount of

[7]For our UNIDO-based measure, averaging the share of female workers across a couple of dozen countries

measurement error on the right-hand side, leading to attenuation bias in the coefficients.

With these caveats in mind, Appendix Tables A3 and A4 replicate the cross-sectional regression estimates in Tables 5 and 6 but using the U.S.-based FL_i indicator instead. Note that because the U.S.-based FL_i are measured in a different industrial classification, this exercise requires concording the international trade data to that classification, rebuilding $FNLX$, and then re-running the gravity instrumentation strategy from scratch. We can see that the results are fully robust to this alternative way of measuring the female intensity of industries.

5.3 Panel Results

The cross-sectional 2SLS results are informative, and allow us to make the clearest case for the causal relationship between comparative advantage and fertility. However, because they do not allow the use of country fixed effects, the cross-sectional results may still suffer from omitted variables problems. As an alternative empirical strategy, we estimate the panel specification (23) on non-overlapping 5-year and 10-year averages from 1962 to 2007. The gravity-based instrumentation strategy is not feasible in a panel setting with fixed effects. On the other hand, country effects allow us to control for a wide range of unobservable time-invariant country characteristics, and identify the coefficient of interest from the variation in $FNLX$ and fertility within a country over time.

The results are presented in Table 7. To control for autocorrelation in the error term, all standard errors are clustered at the country level. Column 1 reports the results for the pooled specification without any fixed effects. The coefficient is remarkably similar to the OLS coefficient from column 1 of Table 5. Column 2 adds country fixed effects. The coefficient on $FNLX$ is nearly unchanged, and significant at the one percent level. Column 3 adds time effects to control for secular global trends, while column 4 adds female educational attainment. The results continue to be highly significant. Columns 5–8 repeat the exercise taking 10-year averages instead.[8] The coefficients are very similar in magnitude and equally significant. Once again, a concern with these estimates is that in the presence of non-manufacturing sectors, a country's $FNLX$ may be mismeasured. Appendix Table A5 replicates the panel results of Table 7 using instead the U.S.-based version of FL_i that includes non-manufacturing sectors. The results are equally robust when using this alternative measure.

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helps alleviate both of these problems.

[8]To be more precise, these are decadal averages for the 1960s, 1970s, and up to 2000s. Since our yearly data are for 1962-2007, the 1960s and the 2000s are averages over less than 10 years.

6 Conclusion

Fertility is an economic decision, and like all economic decisions has long been considered an appropriate – and important – subject of analysis by economists. As trade integration increased in recent decades, there is growing recognition that the impacts of globalization are being felt well beyond the traditional market outcomes such as average wages, skill premia, and (un)employment. This paper makes the case that international trade, or more precisely comparative advantage, matters for this key non-market outcome: the fertility decision.

Our results thus emphasize the heterogeneity of the effects of trade on countries' industrial structures and gender outcomes. At a more conjectural level, to the extent that comparative advantage impacts fertility, it may also impact women's human capital investments, occupational choice, and bargaining power within the household. From a policy perspective, our results suggest that it will be more difficult for countries with technologically-based comparative advantage in male-labor intensive goods to undertake policy measures to reduce the gender gap, potentially leading to a slower pace of women's empowerment. In an increasingly integrated global market, the road to female empowerment is paradoxically very specific to each country's productive structure and exposure to international trade.

Appendix A Proofs

Proof of Proposition 1

The "goods market-clearing curve" and "factor market-clearing curve" have opposite slopes. We therefore need to show that they intersect at least once, since if they do, such intersection is unique. A necessary and sufficient condition for the two curves to intersect is that the "goods market-clearing curve" be above the "factor market-clearing curve" for low values of f^c and below for larger values of f^c.

- As f^c gets arbitrarily close to 1, equality (10) implies that the "goods market-clearing" curve is bounded below by $\frac{1}{1-\eta}$, while (11) indicates that the "factor market-clearing" curve converges to $1 < \frac{1}{1-\eta}$, and therefore lies below the "goods market-clearing" curve.
- On the other hand, when f^c grows arbitrarily large, the "goods market-clearing" curve converges to $\frac{1}{1-\eta}$, while the "factor market-clearing" diverges, and hence lies above the "goods market-clearing" curve.

Thus, the "goods market-clearing" curve is above the "factor market-clearing" curve in the neighborhood of 1, while the opposite holds for large values of f^c. Continuity of the two curves implies existence of an intersection.■

Proof of Lemma 1

The second order condition is precisely inequality (13).■

Proof of Lemma 2

From equation (10), let's try to characterize the behavior of f^c when the patterns of comparative advantage ρ are changing.

Dropping the country reference and substituting for f^{-c}, f is implicitly defined for every ρ by:

$$\left[\frac{1}{\rho}\left(f-1\right)+1\right]^{\alpha}\left[1-\left(1-\eta\right)f\right]+\theta f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)\left(f-1\right)\right]=0$$

that is denoted $x\left(f,\rho\right)=0$.

$$\begin{aligned}\frac{\partial x\left(f,\rho\right)}{\partial\rho} &= - \quad \frac{1}{\rho^{2}}\frac{\alpha\left(f-1\right)}{\frac{1}{\rho}\left(f-1\right)+1}\left[\frac{1}{\rho}\left(f-1\right)+1\right]^{\alpha}\left[1-\left(1-\eta\right)f\right] \\ &+ \quad \frac{1}{\rho^{2}}\left(1-\eta\right)\left(f-1\right)\theta f^{\alpha}\end{aligned}$$

and since $x\left(f,\rho\right)=0$ implies

$$\left[\frac{1}{\rho}\left(f-1\right)+1\right]^{\alpha}\left[1-\left(1-\eta\right)f\right]=-\theta f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)\left(f-1\right)\right],$$

we have

$$\begin{aligned}\frac{\partial x\left(f,\rho\right)}{\partial\rho} &= \frac{1}{\rho^{2}}\frac{\alpha\left(f-1\right)}{\frac{1}{\rho}\left(f-1\right)+1}\theta f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)\left(f-1\right)\right] \\ &+ \frac{1}{\rho^{2}}\left(1-\eta\right)\left(f-1\right)\theta f^{\alpha} \\ &= \frac{1}{\rho^{2}}\frac{\theta f^{\alpha}\left(f-1\right)}{\frac{1}{\rho}\left(f-1\right)+1}\left\{\alpha\left[\eta-\frac{1}{\rho}(1-\eta)\left(f-1\right)\right]+\left(1-\eta\right)\left[\frac{1}{\rho}\left(f-1\right)+1\right]\right\} \\ &= \frac{1}{\rho^{2}}\frac{\theta x^{\alpha}\left(f-1\right)}{\frac{1}{\rho}\left(f-1\right)+1}\left\{\alpha\eta+\left(1-\eta\right)+\left(1-\alpha\right)\frac{1}{\rho}\left(1-\eta\right)\left(f-1\right)\right\}\end{aligned}$$

On the other hand,

$$\begin{aligned}\frac{\partial x\left(f,\rho\right)}{\partial f} &= \frac{1}{\rho}\frac{\alpha}{\frac{1}{\rho}\left(f-1\right)+1}\left[\frac{1}{\rho}\left(f-1\right)+1\right]^{\alpha}\left[1-\left(1-\eta\right)f\right] \\ &- \left(1-\eta\right)\left[\frac{1}{\rho}\left(f-1\right)+1\right]^{\alpha} \\ &+ \frac{\alpha\theta}{f}f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)\left(f-1\right)\right] \\ &- \frac{1}{\rho}\left(1-\eta\right)\theta f^{\alpha}\end{aligned}$$

After substitution

$$\begin{aligned}\frac{\partial x(f,\rho)}{\partial f} &= - \quad \theta f^{\alpha}\frac{1}{\rho}\frac{\alpha}{\frac{1}{\rho}(f-1)+1}\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]\\ &+ \quad \theta f^{\alpha}(1-\eta)\frac{\eta-\frac{1}{\rho}(1-\eta)(f-1)}{1-(1-\eta)f}\\ &+ \quad \theta f^{\alpha}\frac{\alpha}{f}\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]\\ &- \quad \theta f^{\alpha}\frac{1}{\rho}(1-\eta)\end{aligned}$$

taking terms 1 and 3, and 2 and 4 together, we simplify to:

$$\begin{aligned}\frac{\partial x(f,\rho)}{\partial f} &= \theta f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]\frac{\rho-1}{\rho}\frac{\alpha}{f\left[\frac{1}{\rho}(f-1)+1\right]}\\ &+ \theta f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]\frac{\rho-1}{\rho}\frac{\eta(1-\eta)}{[1-(1-\eta)f]\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]}\end{aligned}$$

The implicit function theorem indicates that $f(\rho)$ is well defined and continuously differentiable around ρ such that $x(f(\rho),\rho)=0$; we can now compute the derivative of f with respect to ρ :

$$\begin{aligned}f'(\rho) &= -\frac{1}{\rho^2}\frac{\frac{\theta f^{\alpha}(f-1)}{\frac{1}{\rho}(f-1)+1}\left\{\alpha\eta+(1-\eta)+(1-\alpha)\frac{1}{\rho}(1-\eta)(f-1)\right\}}{\theta f^{\alpha}\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]\frac{\rho-1}{\rho}\left\{\frac{\alpha[1-(1-\eta)f]\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]+\eta(1-\eta)f\left[\frac{1}{\rho}(f-1)+1\right]}{f\left[\frac{1}{\rho}(f-1)+1\right][1-(1-\eta)f]\left[\eta-\frac{1}{\rho}(1-\eta)(f-1)\right]}\right\}}\\ &= -\frac{1}{\rho^2}\frac{1-(1-\eta)f}{\rho-1}\frac{\rho(f-1)f[\alpha\eta\rho+(1-\eta)\rho+(1-\alpha)(1-\eta)(f-1)]}{\alpha[1-(1-\eta)f][\rho\eta-(1-\eta)(f-1)]+\eta(1-\eta)f[(f-1)+\rho]}\\ &= \frac{(1-\eta)f-1}{\rho-1}\frac{(f-1)f}{\rho}\frac{\alpha\eta\rho+(1-\eta)\rho+(1-\alpha)(1-\eta)(f-1)}{\eta\rho[\alpha+(1-\alpha)(1-\eta)f]+(1-\eta)(f-1)[\alpha(f-1)+(1-\alpha)\eta f]}\end{aligned}$$

The second and third terms of the equation are always positive, since $f>1$. And by virtue of (10) and (11), the first term $\frac{(1-\eta)f-1}{\rho-1}>0$. We thus have

$$f'(\rho)>0.$$

■

Proof of Proposition 2

Having established that the female labor demand curve is downward sloping for every level of country $-c$'s female labor force participation and that the female labor supply curve is upward sloping, we have shown uniqueness of an intersection. We now need to show existence of an intersection.

- As λ^c goes to zero (i.e. female labor supply goes to 1), the labor supply curve defined by (12) diverges given that $N'(.) > 0$ and $\lim_{N\to 0} v'(N) = +\infty$, by assumption. The labor demand curve is on the other hand bounded above since it is downward sloping; it therefore lies below the labor supply curve.

- Let's now let λ^c get arbitrarily close to 1, so that ρ^c converges to zero. Equation (11) implies that f^c will converge to 1, so that, by virtue of (10), f^{-c} will converge to some $\bar{f}^{-c} > 1$ such that $\eta + (\gamma^c)^{\eta(1-\alpha)} \left(\bar{f}^{-c}\right)^{-\alpha} \left[1 - (1-\eta)\bar{f}^{-c}\right] = 0$. Thus, the labor demand curve converges to some positive wage $\bar{w}_F^c$. Two cases arise:

  – if $N'(1)\, v'[N(1)] < \bar{w}_F^c$, then the labor supply curve is below the labor demand curve at $\lambda^c \to 1$; the labor supply curve is thus above the labor demand curve in the neighborhood of $\lambda^c = 0$, while below in the neighborhood of $\lambda^c = 1$. Continuity of the two curves implies existence of an intersection, and thus existence of a well-defined female labor market equilibrium.

  – if $N'(1)\, v'[N(1)] \geq \bar{w}_F^c$, then the two curves intersect in $(1, \bar{w}_F^c)$.

The two possibilities are depicted in Figure A1.■

Proof of Proposition 3

We need to prove that the two "reaction" functions $\lambda^c(\lambda^{-c})$ and $\lambda^{-c}(\lambda^c)$ intersect at least once. We have argued that these two curves are decreasing. Furthermore, we note that the two curves are continuous. We next investigate the behavior of $\lambda^c(\lambda)$ as λ gets arbitrarily close to 0 and 1, respectively.

- Since prices in country c are continuous in $\lambda^{-c} = 0$, and $\lim_{\lambda\to 0} v'[N(\lambda)] = +\infty$, $\lambda^c(0)$ is well defined and interior: there exists $\varepsilon^c > 0$, such that $\lambda^c(0) = 1 - \varepsilon^c$.

- Given that $\lambda^c(.)$ is decreasing, we have $\lambda^c(\lambda) \in [0, 1-\varepsilon^c]$, a compact set. Suppose now that λ^{-c} is set arbitrarily close to 1. Then, (11) implies that f^{-c} converges to 1, uniformly with respect to λ^c; (10) in turn implies that f^c converges towards some $\bar{f}^c < \infty$ such that $\left(\bar{f}^c\right)^{-\alpha}\left[1-(1-\eta)\bar{f}^c\right] + \eta(\gamma^c)^{\eta(1-\alpha)} = 0$. Equation (5) indicates that female wages in country c remain bounded above, so that $\lim_{\lambda^{-c}\to 1} \lambda^c(\lambda^{-c}) > 0$.

Thus, the curve $\lambda^{-c}(.)$ cuts $\lambda^c(.)$ at least once, and "from above," as shown in Figure A2 below. This establishes the existence of an equilibrium $\left(\lambda^X, \lambda^Y\right)$.

To show uniqueness, we look at the labor market equilibrium. For an interior solution, $\{(f^c, \lambda^c)\}_{c\in\{X,Y\}}$ are implicitly defined by (16). The conditions for the implicit function theorem hold, so that (16) implies that λ^c can be expressed as a function $\lambda^c(f^c)$ of f^c and exogenous parameters only such that $\lambda^c(.)$ is continuously differentiable and simple algebra yields:

$$\frac{d\lambda^c(f)}{df^c} = -\frac{1-\lambda^c(f)}{f-1} \frac{1 - \frac{1}{1-\eta(1-\alpha)}\alpha\frac{f-1}{f}}{1 - \frac{1}{1-\eta(1-\alpha)}\frac{w"[\lambda^c(f)]}{w'[\lambda^c(f)]}\left[1-\lambda^c(f)\right]}$$

for $\lambda^c(f) < 1$ and $\frac{d\lambda^c(f)}{df^c} = 0$ in the case of a corner solution. Thus, any labor and capital allocations satisfying (15) are characterized by

$$0 \leq -\frac{d\lambda^c(f)}{df^c} \leq \frac{1-\lambda^c(f)}{f-1}. \tag{A.1}$$

We now turn to the system of equilibrium conditions (10) and (11) that are conditional on labor endowments (λ^X, λ^Y). On the one hand, (10) defines a negative *unconditional* relationship between f and f^{-c}; on the other hand, we rewrite (11) as

$$\frac{f^c-1}{1-\lambda^c(f^c)} = \gamma^c \frac{f^{-c}-1}{1-\lambda^{-c}(f^{-c})} \tag{A.2}$$

that can be written

$$u^c(f^c) = \gamma^c u^{-c}\left(f^{-c}\right),$$

where

$$u^c(f) = \frac{f-1}{1-\lambda^c(f)}.$$

Inequality (A.1) implies that $u^c(.)$ is increasing, so that (A.2) defines a positive *unconditional* relationship between f^c and f^{-c}. Thus, the two equilibrium conditions for capital define two curves with opposite slope, implying a unique intersection, since existence was established above. Uniqueness of capital allocation across sectors implies uniqueness of labor force participation decisions.■

Proof of Proposition 4

To move from comparative statics to cross-sectional comparisons, we set $\tilde{\gamma}^c = 1$. Equilibrium conditions (10) and (11) and labor market claring equations (16) are thus symmetric in both $(\lambda^c, \lambda^{-c})$ and (f^c, f^{-c}), implying $\tilde{f}^c = \tilde{f}^{-c} = \frac{1}{1-\eta}$ and $\tilde{\lambda}^c = \tilde{\lambda}^{-c} = \lambda^0$, where λ^0 satisfies (16). Implication (20) becomes for $\tilde{\gamma}^c = 1$:

$$\gamma^c \geq 1 \Longrightarrow \lambda^c \leq \lambda^0 \leq \lambda^{-c}.$$

Finally, since the arguments leading to Proposition 4 assume interior solutions for the fmale labor market equilibrium in both countries, we now address the cases in which the labor market equilibrium is at a corner (i.e. $\lambda^c = 1$ or $\lambda^{-c} = 1$). Without loss of generality, suppose that $\gamma^c \geq 1$.

- If $\lambda^{-c} = 1$, i.e. the F-sector in country $-c$ disappears, then $\lambda^c < 1$ (since λ^c =1 implies that $f^c = 1$, and (10) does not hold for $f^c = f^{-c} = 1$), and the proposition trivially holds. Indeed, if $c's$ comparative advantage in the F-sector is large enough, then c will end up producing all the F-goods in the economy.

- Suppose that instead $\lambda^c = 1$ and $\lambda^{-c} < 1$. Female wages are given by

$$w_F^c = (1-\alpha)\left(\gamma^c \frac{f^{-c}-1}{1-\lambda^{-c}}\right)^{1-\eta(1-\alpha)} \leq N'(1)\, v\left[N(1)\right]$$

$$w_F^{-c} = (1-\alpha)\left(\frac{f^{-c}-1}{1-\lambda^{-c}}\right)^{1-\eta(1-\alpha)} = N'\left(\lambda^{-c}\right) v\left[N\left(\lambda^{-c}\right)\right]$$

and since $\lambda^{-c} < 1$, and $N'(.)\, v[N(.)]$ is decreasing, we have $N'(\lambda^{-c})\, v[N(\lambda^{-c})] > N'(1)\, v[N(1)]$ so that $w_F^{-c} > N'(1)\, v[N(1)] \geq w_F^c$. This implies

$$\gamma^c < 1,$$

a contradiction.

This concludes the proof.■

Appendix B General Form of Preferences

Suppose that preferences over consumption and fertility are given by

$$u(C_F, C_M, N) = \omega(C, N)$$

where C is the consumption bundle, i.e. $C = C_F^{\eta} C_M^{1-\eta}$, $\omega(.)$ is increasing and concave in both arguments, and $\omega_{CN}(.) = \frac{\partial^2 \omega(.)}{\partial C \partial N} > 0$: the marginal utility from consumption increases with the number of children, children being themselves consumers of goods. Since consumer preferences are defined over the consumption bundle $C = C_F^{\eta} C_M^{1-\eta}$, the production and trade equilibrium holding λ fixed characterized in Proposition 1 is unchanged. Agents' indirect utility is now given by

$$\Omega^c(\lambda) = \omega\left[r^c + w_F^c(1-\lambda) + w_M^c, N(\lambda)\right].$$

Female labor supply λ^c is determined by the first-order condition

$$w_F = N'(\lambda^c) \frac{\omega_N(C^c, N^c)}{\omega_C(C^c, N^c)}, \quad \text{(B.1)}$$

where $C^c = r^c + w_F^c(1-\lambda) + w_M^c$, $N^c = N(\lambda^c)$, and $\omega_N(.)$ and $\omega_C(.)$ are partial derivates of $\omega(.)$ with respect to N and C, respectively. Similarly, we will denote $\omega_{UV}(.) = \frac{\partial^2 \omega(.)}{\partial U \partial V}$ for $U, V \in \{C, N\}$. The first-order condition is sufficient if the second-order condition holds, i.e.

$$w_F^2 \omega_{CC}(C^c, N^c) - 2 w_F N'(\lambda^c)\, \omega_{CN}(C^c, N^c) + N"(\lambda^c)\, \omega_N(C^c, N^c) + \left[N'(\lambda^c)\right]^2 \omega_{NN}(C^c, N^c) \leq 0.$$

Since $\omega(.)$ is increasing and concave in both arguments and $\omega_{CN}(.) \geq 0$, a sufficient condition for the second-order condition to hold is identical to condition (13): for every $\lambda \in [0,1]$,

$$N"(\lambda)\, \omega_N[C(\lambda), N(\lambda)] + \left[N'(\lambda)\right]^2 \omega_{NN}[C(\lambda), N(\lambda)] \leq 0, \quad \text{(B.2)}$$

which we will henceforth assume to hold.

Applying the implicit function theorem to first-order condition (B.1) allows us to determine the slope of the female labor supply curve. Since (B.2) implies that the second order condition holds, the slope of the female formal labor supply curve is determined by the sign of the derivative of λ^c with respect to w_F:

$$\omega_C(C^c,N^c) - (1-\lambda^c)N'(\lambda^c)\left[\omega_{CN}(C^c,N^c) - \frac{\omega_N(C^c,N^c)}{\omega_C(C^c,N^c)}\omega_{CC}(C^c,N^c)\right], \tag{B.3}$$

which can be decomposed into the substitution effect (first term) and the income effect (second term), that go in opposite directions. The novelty here relative to the main text is the income effect, which we now examine in greater detail. The first term in square brackets represents the level of complementarity between consumption and fertility: an increase in female wages will translate into higher consumption levels, making the marginal utility of an additional child higher. Thus, this effect works against the substitution effect. The second term captures the decrease in marginal utility of consumption, which also offsets the substitution effect.

Rearranging (B.3) yields the result that the sign of the derivative of the female labor force supply curve is the same as $1-(1-\lambda^c)N'(\lambda^c)\left[\frac{\omega_{CN}(C^c,N^c)\omega_C(C^c,N^c)-\omega_N(C^c,N^c)\omega_{CC}(C^c,N^c)}{\omega_C^2(C^c,N^c)}\right] = 1-(1-\lambda^c)N'(\lambda^c)\frac{\partial}{\partial C}\left[\frac{\omega_N(C^c,N^c)}{\omega_C(C^c,N^c)}\right]$. Thus, the female labor supply curve is upward-sloping (i.e. the wealth effect is sufficiently muted) as long as

$$\frac{\partial}{\partial C}\left[\frac{\omega_N(C,N)}{\omega_C(C,N)}\right] < \frac{1}{M},$$

where $M = \sup_{\lambda\in[0,1]} N'(\lambda)$. The intuition is that the households' increased willingness to pay for children as they get wealthier is not undoing the substitution effect. This assumption is similar to the one made in Galor and Weil (1996).

Appendix C Construction of the Instrument

This Appendix describes the steps necessary to build the instrument for the female content of exports. The construction of the instrument follows Do and Levchenko (2007), and exploits exogenous geographic characteristics of countries together with the empirically observed regularity that trade responds differentially to the standard gravity forces across sectors. For each industry i, we estimate the Frankel and Romer (1999) gravity specification, which relates observed trade flows to exogenous geographic variables:

$$\begin{aligned} LogX_{icd} = {} & \alpha_i + \eta_i^1 ldist_{cd} + \eta_i^2 lpop_c + \eta_i^3 larea_c + \eta_i^4 lpop_d + \eta_i^5 larea_d + \\ & \eta_i^6 landlocked_{cd} + \eta_i^7 border_{cd} + \eta_i^8 border_{cd} \times ldist_{cd} + \\ & \eta_i^9 border_{cd} \times pop_c + \eta_i^{10} border_{cd} \times area_c + \eta_i^{11} border_{cd} \times pop_d + \\ & \eta_i^{12} border_{cd} \times area_d + \eta_i^{13} border_{cd} \times landlocked_{cd} + \epsilon_{icd}, \end{aligned} \tag{C.1}$$

where $LogX_{icd}$ is the log of exports as a share of GDP in industry i, from country c to country d. The right-hand side consists of the geographical variables. In particular, $ldist_{cd}$ is the log of distance between the two countries, defined as distance between the major cities in the two countries, $lpop_c$ is the log of population of country c, $larea_c$ log of land area, $landlocked_{cd}$ takes the value of 0, 1, or 2 depending on whether none, one, or both of the trading countries are landlocked, and $border_{cd}$ is the dummy variable for common border. The right-hand side of the specification is identical to the one Frankel and Romer (1999) use. We use bilateral trade flows from the COMTRADE database, converted to the 3-digit ISIC Revision 3 classification. To estimate the gravity equation, the bilateral trade flows X_{icd} are averaged over the period 1980-2007. This allows us to smooth out any short-run variation in trade shares across sectors, and reduce the impact of zero observations.

Having estimated equation (C.1) for each industry, we then obtain the predicted logarithm of industry i exports to GDP from country c to each of its trading partners indexed by d, $\widehat{LogX}_{icd}$. In order to construct the predicted overall industry i exports as a share of GDP from country c, we then take the exponential of the predicted bilateral log of trade, and sum over the trading partner countries $d = 1, ..., C$, exactly as in Frankel and Romer (1999):

$$\hat{X}_{ic} = \sum_{\substack{d=1 \\ d \neq c}}^{C} e^{\widehat{LogX}_{icd}}.$$

That is, predicted total trade as a share of GDP for each industry and country is the sum of the predicted bilateral trade to GDP over all trading partners. This exercise extends and modifies the Frankel and Romer (1999) methodology in two respects. First, and most importantly, it constructs the Frankel and Romer (1999) predicted trade measures by industry. And second, rather than looking at total trade, it looks solely at exports.

Do and Levchenko (2007) discuss and justify this strategy at length. As mentioned above, the objective is to predict trade patterns, not trade volumes. How can this procedure yield different predictions for $\hat{X}_{ic}$ across sectors if all of the geographical characteristics on the right-hand side of equation (C.1) do not vary by sector? Note that the procedure estimates an individual gravity equation for each sector. Thus, crucially for this strategy, if the vector of estimated gravity coefficients η_i differs across sectors, so will the predicted total exports $\hat{X}_{ic}$ across sectors i within the same country. Indeed, Do and Levchenko (2007) show that the variation in these coefficients across sectors is substantial, generating variation in predicted trade patterns across countries.

There is another potentially important issue, namely the zero trade observations. In our gravity sample, only about two-thirds of the possible exporter-importer pairs record positive exports, in any sector. At the level of individual industry, on average only a third of possible country-pairs have strictly positive exports, in spite of the coarse level of aggregation.[9] We follow the Do and Levchenko (2007) procedure, and deal with zero observations in two ways. First, following the large majority of gravity studies, we take logs of trade values, and thus the baseline gravity estimation procedure ignores zeros. However, instead of predicting in-sample, we use the estimated gravity model to predict out-of-sample. Thus, for those observations that are zero or missing and are not used in the actual estimation, we still predict trade.[10] In the second approach, we instead estimate the gravity regression in levels using

[9] These two calculations make the common assumption that missing trade observations represent zeros (see Helpman et al., 2008).

[10] More precisely, for a given exporter-importer pair, we predict bilateral exports out-of-sample for all 61 sectors as long as there is any bilateral exports for that country pair in at least one of the 61 sectors.

the Poisson pseudo-maximum likelihood estimator suggested by (Santos Silva and Tenreyro, 2006). The advantage of this procedure is that it actually includes zero observations in the estimation, and can predict both zero and non- zero trade values in-sample from the same estimated equation. Its disadvantage is that it assumes a particular likelihood function, and is not (yet) a standard way of estimating gravity equations found in the literature. The main text reports the results of implementing all three approaches. It turns out that all three deliver very similar results, an indication that the zeros problem is not an important one for this empirical strategy.

Armed with a working model for predicting exports to GDP in each industry i, it is straightforward to construct the instrument for the female content of exports, based on predicted export patterns rather than actual ones. That is, our instrument will be, in a manner identical to equation (21):

$$\widehat{FLNX}_c = \sum_{i=1}^{I} \widehat{\omega}_{ic}^{X} FL_i.$$

Here, the predicted share of total exports in industry i in country c, $\widehat{\omega}_{ic}^{X}$, is constructed from the predicted export ratios $\hat{X}_{ic}$ in a straightforward manner:

$$\widehat{\omega}_{ic}^{X} = \frac{\hat{X}_{ic}}{\sum_{i=1}^{I} \hat{X}_{ic}}.$$

Note that even though $\hat{X}_{ic}$ is exports in industry i normalized by a country's GDP, every sector is normalized by the same GDP, and thus they cancel out when we take the predicted export share.

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Table 1: Female Labor Dependence of Sectors

ISIC Code	Sector Name	Dependence
151	Meat, fish, fruit, vegetables, oils and fats	0.36
152	Dairy products	0.25
153	Grain mill, starch products, and prepared animal feeds	0.20
154	Other food products	0.39
155	Beverages	0.23
160	Tobacco products	0.33
171	Spinning, weaving and finishing of textiles	0.37
172	Other textiles	0.47
173	Knitted and crocheted fabrics and articles	0.62
181	Wearing apparel, except fur apparel	0.71
182	Fur and articles of fur	0.41
191	Leather and leather products	0.43
192	Footwear	0.49
201	Sawmilling and planing of wood	0.16
202	Products of wood, cork, straw and plaiting materials	0.18
210	Paper and paper products	0.23
221	Publishing	0.33
222	Printing and service activities related to printing	0.29
223	Reproduction of recorded media	0.35
231	Coke oven products	0.14
232	Refined petroleum products	0.13
233	Nuclear fuel	0.11
241	Basic chemicals	0.15
242	Other chemical products	0.36
243	Man-made fibres	0.22
251	Rubber products	0.23
252	Plastics products	0.27
261	Glass and glass products	0.19
269	Non-metallic mineral products n.e.c.	0.16
271	Basic iron and steel	0.10
272	Basic precious and non-ferrous metals	0.13
273	Casting of metals	0.12
281	Structural metal products, tanks, reservoirs, steam generators	0.12
289	Other fabricated metal products	0.19
291	General purpose machinery	0.16
292	Special purpose machinery	0.14
293	Domestic appliances n.e.c.	0.28

Table 1 (continued): Female Labor Dependence of Sectors

ISIC Code	Sector Name	Dependence
300	Office, accounting and computing machinery	0.34
311	Electric motors, generators and transformers	0.32
312	Electricity distribution and control apparatus	0.30
313	Insulated wire and cable	0.32
314	Accumulators, primary cells and primary batteries	0.26
315	Electric lamps and lighting equipment	0.34
319	Other electrical equipment n.e.c.	0.42
321	Electronic valves and tubes and other electronic components	0.46
322	TV and radio transmitters; telephony and telegraphy apparatus	0.38
323	TV and radio receivers, sound or video apparatus	0.43
331	Medical appliances and instruments	0.38
332	Optical instruments and photographic equipment	0.45
333	Watches and clocks	0.42
341	Motor vehicles	0.09
342	Bodies for motor vehicles; trailers and semi-trailers	0.08
343	Parts and accessories for motor vehicles and their engines	0.21
351	Building and repairing of ships and boats	0.09
352	Railway and tramway locomotives and rolling stock	0.08
353	Aircraft and spacecraft	0.15
359	Transport equipment n.e.c.	0.21
361	Furniture	0.20
369	Manufacturing n.e.c.	0.38
371	Recycling of metal waste and scrap	0.17
372	Recycling of non-metal waste and scrap	0.25
	Mean	0.274
	Min	0.08
	Max	0.71

Table 2: Summary Statistics for Female Labor Need of Exports

	OECD			NON-OECD		
	Panel A: Female Labor Need of Exports					
	Mean	St. Dev	Countries	Mean	St. Dev	Countries
1960s	0.263	0.043	20	0.275	0.077	102
1970s	0.256	0.044	20	0.274	0.082	103
1980s	0.255	0.047	20	0.284	0.100	103
1990s	0.261	0.042	21	0.302	0.109	123
2000s	0.256	0.032	21	0.293	0.122	128
	Panel B: Fertility Rates					
	Mean	St. Dev	Countries	Mean	St. Dev	Countries
1960s	2.80	0.460	20	6.15	1.367	102
1970s	2.13	0.457	20	5.75	1.593	103
1980s	1.74	0.261	20	5.13	1.758	103
1990s	1.63	0.248	21	3.99	1.847	123
2000s	1.64	0.254	21	3.38	1.704	128

Table 3: Female Labor Need of Exports: Top 10 and Bottom 10 Countries, 1980-2007.

Highest Female Labor Need of Exports		*Lowest Female Labor Need of Exports*	
Lesotho	0.650	Algeria	0.146
Haiti	0.572	Angola	0.144
Bangladesh	0.557	Kazakhstan	0.141
Mauritius	0.528	Venezuela, RB	0.140
Sri Lanka	0.525	Saudi Arabia	0.138
Honduras	0.486	Kuwait	0.138
Cambodia	0.485	Nigeria	0.137
El Salvador	0.471	Gabon	0.137
Nepal	0.465	Iraq	0.135
Dominican Republic	0.461	Libya	0.134

Table 4: Female Labor Need of Exports: Top 10 and Bottom 10 Changers since 1960s.

Largest Increase in Female Labor Need of Exports		*Largest Decrease in Female Labor Need of Exports*	
Cambodia	0.410	Mozambique	-0.097
Honduras	0.311	Rwanda	-0.112
Haiti	0.269	Sudan	-0.112
Sri Lanka	0.225	Ecuador	-0.129
Tunisia	0.211	Congo, Rep.	-0.132
Albania	0.210	Chad	-0.147
Morocco	0.196	Angola	-0.159
El Salvador	0.186	Yemen, Rep.	-0.160
Madagascar	0.182	Niger	-0.170
Nicaragua	0.169	Timor-Leste	-0.281

Note: Change is calculated as the difference between the average Female Labor Need of Exports in 2000 and that in 1960.

Table 5: Cross-Sectional Results, 1980-2007

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
Dependent Variable: (Log) Fertility Rate						
(Log) Female Labor	-0.29***	-0.20***	-0.37***	-0.47***	-0.57***	-0.56***
Need of Exports	(0.080)	(0.057)	(0.128)	(0.085)	(0.131)	(0.137)
(Log) Openness	-0.00	0.01	-0.01	0.01	0.01	0.01
	(0.037)	(0.032)	(0.037)	(0.032)	(0.034)	(0.034)
(Log) GDP per capita	-0.39***	-0.26***	-0.40***	-0.27***	-0.28***	-0.28***
	(0.020)	(0.023)	(0.020)	(0.023)	(0.024)	(0.025)
Constant	5.48***	4.17***	5.81***	5.23***	5.61***	5.57***
	(0.296)	(0.314)	(0.480)	(0.362)	(0.514)	(0.540)
R^2	0.630	0.859				
			First Stage			
Dependent Var. (Log) FLNX						
(Log) Predicted FLNX			3.23***	3.04***		
			(0.342)	(0.373)		
(Log) Predicted FLNX					2.43***	
(out of sample)					(0.469)	
(Log) Predicted FLNX						1.00***
(Poisson)						(0.201)
F-test			43.02	34.69	32.21	27.24
First Stage R^2			0.400	0.534	0.402	0.392
Region Dummies	no	yes	no	yes	yes	yes
Observations	145	145	145	145	145	145

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. All variables are averages over the period 1980-2007 and in natural logs. Variable definitions and sources are described in detail in the text.

Table 6: Robustness: Cross-Sectional 2SLS Results, 1980-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	no outliers	no OECD	no Sub-Saharan Africa	no Middle East & North Africa	Full	Full	Full	Full
Dependent Variable: (Log) Fertility Rate								
(Log) Female Labor	-0.48***	-0.47***	-0.59***	-0.42***	-0.41***	-0.40***	-0.34***	-0.42***
Need of Exports	(0.121)	(0.082)	(0.161)	(0.087)	(0.092)	(0.096)	(0.089)	(0.093)
(Log) Openness	0.02	0.04	0.01	0.01	0.03	0.07	-0.03	0.01
	(0.034)	(0.037)	(0.053)	(0.031)	(0.041)	(0.044)	(0.042)	(0.034)
(Log) GDP per capita	-0.26***	-0.32***	-0.29***	-0.29***	-0.25***	-0.27***	-0.29***	-0.26***
	(0.025)	(0.026)	(0.030)	(0.024)	(0.032)	(0.033)	(0.031)	(0.030)
(Log) Female					-0.11**			
Educational Attainment					(0.046)			
Child Labor Indicator						0.01***		
						(0.002)		
Gini Coeff							0.78***	
							(0.302)	
Polity 2 Indicator								0.00
								(0.005)
Constant	5.17***	5.44***	5.85***	5.27***	4.88***	4.55***	4.72***	4.97***
	(0.499)	(0.348)	(0.713)	(0.365)	(0.438)	(0.449)	(0.372)	(0.439)
First Stage: Dependent Variable Log FLNX								
(Log) Predicted FLNX	2.69***	3.14***	2.55***	2.94***	2.97***	2.99***	3.12***	3.04***
	(0.400)	(0.407)	(0.398)	(0.400)	(0.362)	(0.457)	(0.507)	(0.427)
F-test	32.81	30.62	32.84	35.59	31.74	29.45	20.98	35.05
Region Dummies	yes	yes	yes	yes	yes	yes	yes	yes
First Stage R^2	0.439	0.547	0.542	0.497	0.558	0.513	0.527	0.548
Observations	135	125	104	129	125	103	102	144

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. All variables are averages over the period 1980-2007 and in natural logs. Variable definitions and sources are described in detail in the text.

Table 7: Panel Results, 1962-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Five-Year Averages				Ten-Year Averages			
Dependent Variable: (Log) Fertility Rate								
(Log) Female Labor	-0.37***	-0.34***	-0.22***	-0.22***	-0.38***	-0.36***	-0.24***	-0.23***
Need of Exports	(0.067)	(0.077)	(0.058)	(0.061)	(0.069)	(0.093)	(0.069)	(0.072)
(Log) Openness	-0.02	-0.18***	-0.02	-0.00	-0.02	-0.18***	-0.02	-0.00
	(0.028)	(0.041)	(0.031)	(0.034)	(0.028)	(0.049)	(0.036)	(0.039)
(Log) GDP per capita	-0.38***	-0.35***	-0.18***	-0.18***	-0.38***	-0.37***	-0.20***	-0.19***
	(0.019)	(0.051)	(0.043)	(0.047)	(0.019)	(0.059)	(0.048)	(0.051)
(Log) Female				-0.00				-0.01
Educational Attainment				(0.038)				(0.041)
Country FE	no	yes	yes	yes	no	yes	yes	yes
Year FE	no	no	yes	yes	no	no	yes	yes
R^2	0.576	0.885	0.937	0.936	0.584	0.895	0.943	0.942
Observations	1,247	1,247	1,247	1,102	627	627	627	554

Notes: Standard errors clustered at the country level in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. All of the variables are 5-year averages (left panel) or 10-year averages (right panel) over the time periods spanning 1962-2007, and in natural logs. Variable definitions and sources are described in detail in the text.

Appendix Table A1: Least and Most Female-Intensive Sectors, U.S. Data

Least Female-Intensive	FL_i	Most Female-Intensive	FL_i
Logging	5.4	Other apparel and accessories	56.3
Coal Mining	5.7	Leather tanning and finishing	56.3
Cement, concrete, lime, and gypsum	10.3	Retail bakeries	58
Sawmills and wood preservation	11.3	Specialized design services	58
Nonmetallic mineral mining and quarrying	11.5	Cut and sew apparel	66.1

Appendix Table A2: Summary Statistics, U.S.-based measure of FL

	Mean	Min	Max	SD	N
Manufacturing	29.7	10.3	66.1	13.6	78
Non-manufacturing	25.8	5.4	58	15.6	15

Appendix Table A3: Cross-Sectional Results, U.S.-Based Measure of FL_i, 1980-2007

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	2SLS	2SLS	2SLS	2SLS
Dependent Variable: (Log) Fertility Rate						
(Log) Female Labor	-0.45***	-0.34***	-0.80***	-0.65***	-0.70***	-0.63***
Need of Exports	(0.111)	(0.080)	(0.199)	(0.120)	(0.164)	(0.145)
(Log) Openness	-0.00	0.01	-0.01	0.01	0.01	0.01
	(0.037)	(0.031)	(0.041)	(0.031)	(0.031)	(0.031)
(Log) GDP per capita	-0.37***	-0.25***	-0.37***	-0.24***	-0.24***	-0.24***
	(0.021)	(0.022)	(0.022)	(0.021)	(0.022)	(0.021)
Constant	5.82***	4.56***	6.96***	5.57***	5.75***	5.50***
	(0.340)	(0.327)	(0.616)	(0.396)	(0.528)	(0.476)
R^2	0.644	0.865				
			First Stage			
Dependent Var. (Log) FLNX						
(Log) Predicted FLNX			1.77***	1.61***		
			(0.236)	(0.246)		
(Log) Predicted FLNX					1.15***	
(out of sample)					(0.250)	
(Log) Predicted FLNX						.984***
(Poisson)						(0.179)
F-test			19.37	15.28	9.52	11.32
First Stage R^2			0.346	0.451	0.334	0.386
Region Dummies	no	yes	no	yes	yes	yes
Observations	149	149	145	145	145	145

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. All variables are averages over the period 1980-2007 and in natural logs. Variable definitions and sources are described in detail in the text.

Appendix Table A3: Robustness: Cross-Sectional 2SLS Results, U.S.-Based Measure of FL_i, 1980-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	no outliers	no OECD	no Sub-Saharan Africa	no Middle East & North Africa	Full	Full	Full	Full
Dependent Variable: (Log) Fertility Rate								
(Log) Female Labor	-0.84***	-0.70***	-0.80***	-0.52***	-0.56***	-0.51***	-0.35***	-0.60***
Need of Exports	(0.206)	(0.132)	(0.170)	(0.109)	(0.110)	(0.101)	(0.102)	(0.124)
(Log) Openness	0.03	0.04	0.00	0.00	0.02	0.05	-0.04	0.01
	(0.033)	(0.036)	(0.048)	(0.030)	(0.038)	(0.038)	(0.038)	(0.032)
(Log) GDP per capita	-0.23***	-0.28***	-0.26***	-0.26***	-0.23***	-0.26***	-0.26***	-0.23***
	(0.024)	(0.025)	(0.028)	(0.023)	(0.030)	(0.029)	(0.030)	(0.025)
(Log) Female					-0.09**			
Educational Attainment					(0.043)			
Child Labor Indicator						0.01***		
						(0.002)		
Gini Coeff							0.71**	
							(0.278)	
Polity 2 Indicator								-0.00
								(0.005)
Constant	6.07***	5.91***	6.42***	5.34***	5.24***	4.89***	4.63***	5.30***
	(0.682)	(0.421)	(0.636)	(0.364)	(0.437)	(0.445)	(0.411)	(0.441)
First Stage: Dependent Variable Log FLNX								
(Log) Predicted FLNX	1.13***	1.69***	1.58***	1.61***	1.63***	1.69***	1.77***	1.58***
	(0.197)	(0.294)	(0.261)	(0.275)	(0.240)	(0.284)	(0.315)	(0.261)
F-test	9.97	16.24	13.93	14.57	16.71	16.94	13.86	14.91
Region Dummies	yes	yes	yes	yes	yes	yes	yes	yes
First Stage R^2	0.359	0.454	0.487	0.450	0.497	0.552	0.516	0.455
Observations	135	125	104	129	125	103	102	144

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. All variables are averages over the period 1980-2007 and in natural logs. Variable definitions and sources are described in detail in the text.

Appendix Table A5: Panel Results, U.S.-Based Measure of FL_i, 1962-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Five-Year Averages				Ten-Year Averages			
Dependent Variable: (Log) Fertility Rate								
(Log) Female Labor	-0.61***	-0.55***	-0.23***	-0.19**	-0.62***	-0.61***	-0.27**	-0.22**
Need of Exports	(0.092)	(0.103)	(0.086)	(0.092)	(0.096)	(0.122)	(0.102)	(0.109)
(Log) Openness	-0.01	-0.15***	-0.01	0.00	-0.01	-0.15***	-0.01	0.00
	(0.028)	(0.040)	(0.031)	(0.033)	(0.029)	(0.047)	(0.035)	(0.038)
(Log) GDP per capita	-0.35***	-0.35***	-0.19***	-0.18***	-0.35***	-0.37***	-0.20***	-0.20***
	(0.021)	(0.048)	(0.042)	(0.045)	(0.021)	(0.055)	(0.046)	(0.049)
(Log) Female				0.01				0.00
Educational Attainment				(0.040)				(0.043)
Country FE	no	yes	yes	yes	no	yes	yes	yes
Year FE	no	no	yes	yes	no	no	yes	yes
R^2	0.594	0.889	0.936	0.934	0.602	0.899	0.942	0.940
Observations	1,247	1,247	1,247	1,102	627	627	627	554

Notes: Standard errors clustered at the country level in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. All of the variables are 5-year averages (left panel) or 10-year averages (right panel) over the time periods spanning 1962-2007, and in natural logs. Variable definitions and sources are described in detail in the text.

Figure A1. Female Formal Labor Market Equilibrium

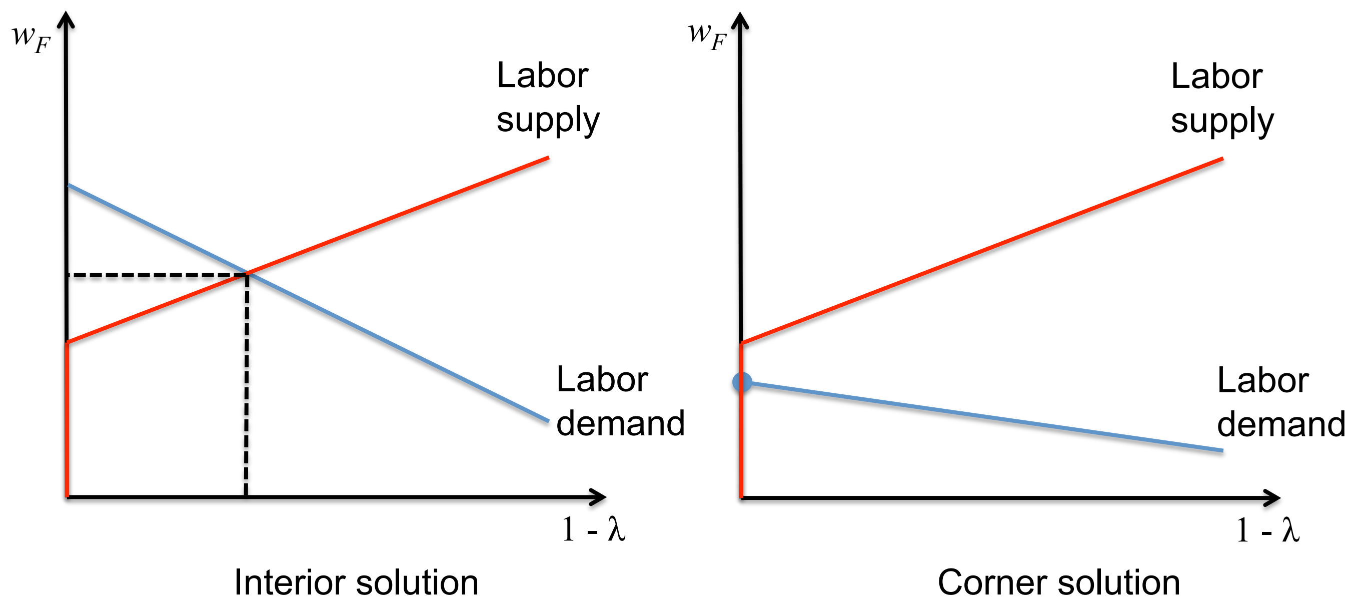

Figure A2. Equilibrium Female Labor Force Participation