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## Desire and Development

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# Desire and Development

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preliminary -- do not circulate

**Abstract.** This paper sets up a unified growth model and explores the impact of gender differences in the desire for sex and the distribution of power in the household for the onset of the demographic transition and the take-off to growth. Depending on the price and efficacy of modern contraceptives, the gender wage gap, and female bargaining power the model assumes one of two possible solutions. At the traditional equilibrium, contraceptives are not used, fertility is high and education and growth are low. At the modern equilibrium, contraceptives are used, fertility is low and further declining with increasing income, and education and growth are high. The theory motivates an endogenous preference reversal. At the traditional equilibrium (i.e. in poor economies) men want to have more children than women whereas at the modern equilibrium (in developed economies) men prefer fewer children than women. Female empowerment leads to lower fertility and more education at the traditional equilibrium and to an earlier onset of the demographic transition and the take-off to modern growth.

*Keywords:* fertility, sex, contraceptive use, education, economic development.

*JEL:* O40; I25; J10; N30.

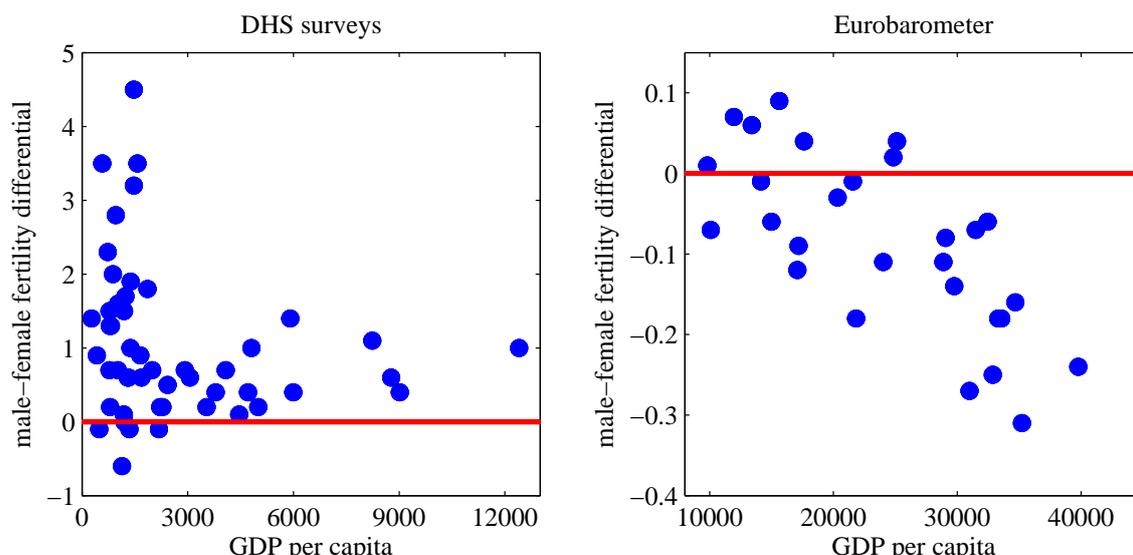
## 1. INTRODUCTION

Humans like to have sex. While most readers may regard this insight as obvious, the economics literature provides also supporting evidence that sex is indeed a utility enhancing activity (Blanchflower and Oswald, 2004). Naturally this appears to be true for men and women. Kahneman et al. (2004), for example, find that sex is the activity that provides the single largest amount of happiness for a sample of U.S. American women. Men, however, appear to like sex even more than women. Evolutionary psychology argues that there are good reasons that men evolved to desire sex more strongly than women (Trivers, 1972; Wright, 1994), a view that has been confirmed by countless psychological studies. Baumeister et al. (2001) survey the literature and conclude “All the evidence we have reviewed points toward the conclusion that men desire sex more than women...We did not find a single study, on any of nearly a dozen different measures, that found women had a stronger sex drive than men...Although most findings pertain to modern America, a smattering of findings from other cultures continues to depict the male sex drive as stronger.” (p. 269). For the present study it is particularly relevant that in marriage (or long-term relationships) men but not women consistently report that they would prefer to have sex more often (see e.g. Aard, 1977; Julien et al., 1992).

A stronger male sex drive in marriage explains why, *ceteris paribus*, men prefer to have more children than women, as long modern contraceptives are unavailable or unaffordable. It creates a mechanism through which the gender-specific desire for sex and female bargaining power become decisive for the fertility transition and economic development. In order to corroborate this claim the present paper develops a gender-based unified growth theory built upon the conventional mechanism of the child quantity-quality trade-off and the importance of education for economic growth. At the traditional equilibrium, higher female bargaining power leads to less fertility and better education, even if there is no gender wage gap because women desire to have sex less strongly than men.

The model predicts a preference reversal. At the modern equilibrium, men prefer to have fewer children than women because the use of contraceptives has decoupled sexual activity from fertility. Consequently, men prefer to spend more time and money on having sex and less on having children. Education at the modern equilibrium is independent from the desire for sex (and its distribution within the household) because a higher desire for sex leaves the marginal cost of education unaffected. Without the use of modern contraceptives, however, there is a tight link between sexual

Figure 1: Preferred Fertility: Female – Male (50 Developing Countries vs 29 European Countries)



Left: mean ideal number of children, men minus women; from ICF (2012), most recent survey years, avg. survey year 2006. Right: difference between mean female and mean male answers to the question “What would be the ideal number of children you would like to have or would have liked to have had?” asked in 2006; Q3 taken from the Eurobarometer (Testa, 2006, Table 4). PPP GDP per capita in the country-specific year of the survey, RDGPE from Feenstra et al., 2013.

intercourse and fertility and men prefer to have more children than women due to their stronger desire for sex.

Figure 1 illustrates the preferences reversal with cross-country data. The panel on the left hand side shows the difference between country averages of men’s ideal number of children minus women’s ideal number of children for 50 developing countries. The data is taken from the available DHS surveys (ICF, 2012) whereby in case of multiple surveys for a country only the most recent survey has been taken into account. The average survey year is 2006. The abscissa shows the associated country GDP per capita of the survey year, taken from Feenstra et al. (2013). For these developing countries, aspired fertility is high (at an average of 5.2) and income is low (at an average of 3200 international Dollars). Many countries in the sample are from Sub Saharan Africa with a particularly low prevalence rate of modern contraceptives (on average 20 among married women). In most countries of the sample men prefer to have more children than women (see also Bankole and Singh, 1998, for an earlier observation of this fact).

The panel on the right hand side of Figure 1 shows the gender differential in the ideal number of children for 29 European countries, taken from the Eurobarometer (Testa, 2006). In these countries income per capita is high (on average 25700 international Dollars), education is high and fertility is low and in many countries below replacement level (the average desired fertility is 2.34). In most of

the countries men prefer a lower number of children than woman. Moreover, the absolute distance between male and female preferred fertility has narrowed substantially.<sup>1</sup>

This paper contributes to the literature on unified growth theory by investigating the take-off from quasi-stagnation to modern growth and by emphasizing the importance of the fertility transition and the child quality-quantity trade-off for successful long-run development.<sup>2</sup> It focusses on a novel channel namely a gender differential in the desire for sex in interaction with gender bargaining power and the use of (modern methods of) contraception. The study extends Strulik (2014) by replacing the unisex, unitary household with a cooperative bargaining of husband and wife, and by investigating several channels through which a gender differential in bargaining power (wage discrimination, gender bias in education) matters for economic development.

The role of gender differences for economic development has been investigated by many other studies focussing on, for example, gender differences in physical strength (Galor and Weil, 1996; Kimura, Yasui, 2010), in education (Lagerloef, 2003; Hazan and Zoabi, 2013; Hiller, 2014), and in child rearing costs (de la Croix and Vander Donckt, 2010). Moreover, there are a couple of studies investigating the role of female empowerment for the demographic transition in a partial equilibrium context or in a model of exogenous economic growth (see Eswaran, 2002; Iyigun and Walsh, 2007; Kimura, 2013).

So far, gender differences in the desire for sex and the decision to use modern contraceptives remained unexplored in the available literature. Like Strulik (2014), Bhattacharya and Chakraborty (2014) investigate the role of contraceptives for development when decisions are made by a unitary household but neglect the utility enhancing motive for sexual intercourse. Prettnner and Strulik (2014) investigate the role of traditional religion for contraceptive use and its impact on the demographic transition and long-run economic growth. There exists supporting evidence that unequal gender power is harmful for economic growth (Dollar and Gatti, 1999; Klasen, 1999, 2002; Knowles et al., 2002). Most of the macro studies focus on the impact of gender-biased education or wages. There exists, however, empirical support from micro studies on the negative association between various measures of female empowerment and contraception and fertility (see e.g. Dyson and Moore,

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<sup>1</sup> There are, of course, other, complementing mechanisms explaining why women prefer fewer children than men at low levels of economic development. Two of these will be integrated in the analysis in form of extensions of the basic model by letting female bargaining power and female education depend on the level of development. These alternatives, however, cannot explain a reversal of wanted fertility at high levels of development. An extensive discussion of potential determinants of male vs. female fertility preferences is provided by Mason and Taj (1987).

<sup>2</sup> For unified growth see Galor and Weil (2000), Kögel and Prskawetz (2001), Jones, 2001, Lucas (2002), Galor and Moav (2002, 2006), Doepke (2004), Cervelatti and Sunde (2005), Galor and Mountford (2008), Strulik and Weisdorf (2008) and many others. See Galor (2005, 2011) for surveys.

1983; Schuler and Hashemi, 1994; Cleland et al., 1996; Nguyen-Dinh, 1997; Hogan et al., 1999; Rao et al., 2014; see Mason, 1997, for an overview)). Bailey (2010, 2013) shows that the increase in uptake of oral contraception in the U.S. had negative impact on fertility and a positive impact on education and income of subsequent generations. With respect to developing countries contraceptive is frequently regarded as the leading proximate cause of the fertility decline (e.g. Bongaarts and Potter, 1983; Westoff and Bankole, 2011; Lule et al., 2007; Darroch and Sing, 2013).

Duflo (2012) reviews the micro evidence and argues that the economic responses to women empowerment are probably too weak to initiate a self-sustained process of economic development and further rising female power. This paper proposes a mildly more optimistic outlook by showing that female empowerment may nudge households towards an earlier uptake of modern contraceptives and thus lead to an earlier onset of the demographic transition. One problem that complicates the empirical identification of an influence of female empowerment on family outcomes is that frequently male education is found to be of similar importance as female education (e.g. Nguyen-Dinh, 1997). The model below predicts a negative impact of male education on fertility if male and female education evolve in sync or if only male education rises and female education or female wage income are sufficiently low. But the model predicts also that female power in family decision making (holding men's and women's education constant) exerts a negative influence on fertility. This influence may be hard to identify in the data, in particular when female-male ratios of education or income are used as measure of female empowerment. Nevertheless, the present paper agrees that the view that "the empowerment and autonomy of women ... is essential for the achievement of sustainable development" (United Nations, 1995, p. 194) may be exaggerated. Instead, the theory developed below argues that contraceptive use and the onset of the demographic transition are essential for sustainable development and that female empowerment, *ceteris paribus*, is helpful to reach this tipping point of human development earlier. Since the onset of the demographic transition is a strong predictor of subsequent economic growth (Dalgaard and Strulik, 2013), the theory corroborates the view that female empowerment is an important determinant of comparative economic development.

The paper is organized as follows. The next section sets up the basic model and derives the main results at the household level. Section 3 and 4 investigate the implications for steady state growth and transitional dynamics. In order to establish the gender-specific desire for sex as a stand-alone determinant of fertility, contraceptive use, and economic development, the basic model ignores

any gender bias in education and treats wage discrimination as well as female say in household decisions as parametrically given. Section 5 adds more realism by firstly introducing endogenously evolving wage discrimination and gender power in the household. For simplicity these features are modeled “in reduced form”. Doepke and Tertilt (2009) and Fernandez (2010) provide a possible micro-foundation by arguing that fathers tend to act in the interest of their daughters. Secondly, section 5 introduces, inspired by Lagerloef (2003), an endogenous gender bias in education. Section 6 concludes.

## 2. THE BASIC MODEL

Consider an economy at time  $t$  populated by a measure  $L_t$  of adults. One half of the adult generation consists of identical males and identical females, respectively. A pair of male and female adults form a household. There are potentially two gateways of female discrimination. One is wage discrimination at the labor market such that women earn a fraction  $\delta$  of the male wage per unit of human capital supplied,  $0 < \delta \leq 1$ . The other dimension is the wife’s bargaining power in household decision making  $\theta$ ,  $0 \leq \theta \leq 1/2$ . In the benchmark model we take empowerment and wage discrimination as exogenously given. In the extension of Section 5 female bargaining power and wage discrimination are allowed to evolve endogenously. A superscript  $j = \{F, M\}$  indicates whether a variable or parameters is assigned to females or males. Variables without superscript are shared by both sexes.

At any given time, firms produce output according to the production function  $y_t = h_t^M \ell_t^M + \delta h_t^F \ell_t^F$ , in which  $\ell_t^j$  is employment and  $h_t^j$  is human capital of gender  $j$ . The wage per unit of human capital is thus unity for males and  $\delta$  for females,  $0 < \delta \leq 1$ . The wage gap could, for example, be motivated by gender-specific selection into occupations, by inferior job experience of women due to less hours of work supplied (see below), by greater physical strength of men (Galor and Weil, 1996), or by outright discrimination.

Adults experience utility from consumption, from having children, from their children’s human capital (potential income), and from having sex. In order to focus on the impact of gender-specific sex preferences we assume that males and females share the same preferences aside from the preference for sex. Moreover we focus on sex within the household, implying that sex  $s_t$ , children  $n_t$ , and education of children  $h_{t+1}$ , are public goods within the household and consumption  $c_t^j$  is a private good. As it will become clear below, consumption could alternatively be a public good

as well without implications for the results. For simplicity we neglect infant and child mortality. Moreover, we assume in the basic model that there is no gender bias in education and we rule out sex-specific birth control such that half of all offspring are of either sex. In order to derive an analytical solution, utility functions are assumed to be separable and logarithmic. This means that the household maximizes

$$\begin{aligned} V &= (1 - \theta) \{ \log c_t^M + \alpha \log n_t + \gamma \log h_{t+1} + \sigma^M \log s_t \} + \theta \{ \log c_t^F + \alpha \log n_t + \gamma \log h_{t+1} + \sigma^F \log s_t \} \\ &= (1 - \theta) \log c_t^M + \theta \log c_t^F + \alpha \log n_t + \gamma \log h_{t+1} + [(1 - \theta)\sigma^M + \theta\sigma^F] \log s_t. \end{aligned} \quad (1)$$

The weights  $\alpha$ ,  $\gamma$ , and  $\sigma^j$  identify the relative importance of children, education, and sex in utility. We assume  $\gamma < \alpha$ , which ensures that adults prefer to have children even if they could be avoided without cost (i.e.  $n_t > 0$  for  $p = 0$ , see below). Furthermore we focus on the case  $\sigma^M \geq \sigma^F$ , i.e. we assume that men like sex no less than women and potentially much more.

Men and women are endowed with one unit of time, which is spent on working, child rearing, and having sex. Let the time cost of child bearing and rearing that is immutably incurred by women denoted by  $\epsilon$ ,  $\epsilon \geq 0$ . How the remainder of time cost of child rearing, denoted by  $\phi$ , is distributed among husband and wife depends on the degree of empowerment. Completely powerless women bear all the burden of child-rearing whereas child rearing duties are distributed equally under equality of power of husband and wife. This means that women spend a total time of  $\epsilon + (1 - \theta)\phi$  on rearing per child and men spend  $\theta\phi$ . Assuming a time cost of sex, denoted by  $\tau$ , prevents that sexual activity increases without bound in a growing economy. Alternatively, we could use a satiation level or a physical upper limit for sex without changing the results. Acknowledging an arbitrarily small time cost of sex avoids to discuss such corner solution. Altogether this means that the households' budget constraint is given by

$$h_t^F [1 - \epsilon n_t - (1 - \theta)\phi n_t - \tau s_t] + \delta h_t^M [1 - \theta\phi - \tau s_t] = c_t^F + c_t^M + e_t n_t + p_t u_t, \quad (2)$$

in which  $e_t$  is investment in (formal) education. This formulation assumes that education is performed outside the household at school. Outsourcing education avoids to discuss which partner is in charge of educating the children.

For simplicity, we measure sex  $s_t$  such that a unit of  $s_t$  implies a unit of  $n_t$  without the use of modern contraceptives. This number may be thought of as already taking into account costless traditional methods of contraception, like breastfeeding or withdrawal. For completeness, we note

the existence of an upper limit of fertility, given by female reproductive capacity,  $\bar{n}$ . In the analysis below, however, fertility will be assumed to always lie below its biological maximum, in line with the historical evidence. The parameter  $\mu$  controls the effectiveness of modern contraceptives. A unit of modern contraceptives prevents the birth of  $\mu$  children. Taking the corner solution into account, the number of births is

$$n_t = \min \{s_t - \mu u_t, \bar{n}\}, \quad (3)$$

in which  $u_t$  is household demand for modern contraceptives.

Human capital is produced according to the production function

$$h_{t+1}^j = A e_t^j, \quad (4)$$

in which  $e_t^j$  is the time spent on education per child of gender  $j$ . The basic model abstracts from a gender bias in education such that  $h_t^M = h_t^F \equiv h_t$ . The linearity in  $e_t$  is necessary for the existence of positive long-run growth, but of no importance otherwise. In Section 5 we show robustness of results for a model version with decreasing returns in education.

Households maximize (1) subject to (2)–(4), given non-negativity constraints on all variables. The interior solutions for consumption, fertility, education, and contraceptive use, and sex are  $c_t^F = \theta c_t$ ,  $c_t^M = (1 - \theta)c_t$ , and

$$c_t = \frac{(1 + \delta)h_t}{1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M} \quad (5a)$$

$$n_t = \frac{(\alpha - \gamma)(1 + \delta)\mu h_t}{[1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] \{\mu\epsilon\delta h_t + \mu\phi h_t [\theta\sigma^F + (1 - \theta)\sigma^M] - p\}} \quad (5b)$$

$$e_t = \frac{\gamma \{\mu\epsilon\delta + \mu\phi [\theta\sigma^F + (1 - \theta)\sigma^M] - p\}}{(\alpha - \gamma)\pi_t\mu} \quad (5c)$$

$$u_t = \left( \frac{\theta\sigma^F + (1 - \theta)\sigma^M}{\mu\tau(1 + \delta)h_t + p} - \frac{\alpha - \gamma}{\mu\epsilon\delta + \mu\phi [\theta\sigma^F + (1 - \theta)\sigma^M] - p} \right) \frac{(1 + \delta)h_t}{1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M}. \quad (5d)$$

For comparison it is interesting to compute the (constrained-) unilaterally optimal fertility level from perspective of husband and wife. Maximizing  $\log c_t^j + \alpha \log n_t + \gamma \log h_{t+1} + \sigma^j \log s_t$  with respect to (2)–(4) provides desired fertility

$$n_t^j = \frac{(\alpha - \gamma)(1 + \delta)\mu h_t}{[1 + \alpha + \sigma^j] \{\mu\epsilon\delta h_t + \mu\phi h_t [\theta\sigma^F + (1 - \theta)\sigma^M] - p\}} \quad (6)$$

for  $j = F, M$ . Taking the derivative with respect to  $\sigma^j$  verifies the following result.

LEMMA 1. *If men desire sex more strongly than women, then they prefer to have fewer children than women when couples use modern contraceptives.*

This, perhaps surprising, non-Darwinian result reflects the impact of contraceptives. When individuals like sex a lot, they prefer to have less kids. Since sex is costly in terms of time and money individuals with a stronger desire for sex prefer to partly substitute more sex for fewer children. This means that men prefer smaller families than women when they face a stronger desire for sex.

Returning to the bargaining solution of the household we inspect the impact of female empowerment

PROPOSITION 1. *Increasing female negotiation power  $\theta$*

- (1) *leads to better child education  $e_t$  if there is either wage discrimination (for  $\delta < 1$ ) or men desire sex more strongly (for  $\sigma^M > \sigma^F$ ).*
- (2) *leads to more consumption of both partners  $c_t$  if men desire sex more strongly (for  $\sigma^M > \sigma^F$ )*
- (3) *has generally ambiguous effect on fertility. It leads to raising fertility if there is no wage discrimination and men prefer sex more strongly. It leads less to fertility if there is wage discrimination and no gender difference in sexual desires.*

Results (1) and (2) are immediately observed from inspection of (5a) and (5b). To verify result (3) we take the derivative

$$\begin{aligned} \frac{\partial n_t}{\partial \theta} = & - (1 - \delta)(1 + \delta)(\alpha - \gamma) [1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] \phi\mu^2 h_t^2 / D^2 \\ & + (\sigma^M - \sigma^F)(1 + d)(\alpha - \gamma) \{ \mu\epsilon\delta + \mu\phi [\theta\sigma^F + (1 - \theta)\sigma^M] - p \} \mu h_t / D^2, \end{aligned} \quad (7)$$

in which  $D$  is the denominator of (5b). Observe that the first term is negative for  $\delta < 1$  and that the second term is positive for  $\sigma^M > \sigma^F$ . The first term reflects the conventional child quality-quantity trade-off. With less wage discrimination, women contribute more to family income, which raises the opportunity cost of having children, which leads to less fertility and more education. Recalling Lemma 1 the positive impact through the second term is also intuitive. Since men prefer to have fewer children than women when they face a higher desire for sex, the negotiated fertility level of the family rises with raising female empowerment. As a result, the aggregate response of fertility to female empowerment is ambiguous. It is positive if the sex-differential effect dominates and negative if the wage discrimination effect dominates.

PROPOSITION 2. *Modern contraceptives are used ( $u_t > 0$ ) if and only if human capital is sufficiently high compared to the price of modern contraceptives that is for*

$$h_t > \bar{h} \equiv \frac{p}{\mu} \cdot \frac{\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M}{[\theta\sigma^F + (1 - \theta)\sigma^M][\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta] - (\alpha - \gamma)(1 + \delta)\tau}. \quad (8)$$

*Ceteris paribus, the threshold  $\bar{h}$  is*

- (1) *increasing in the price of contraceptives  $p$ , the weight of children in utility  $\alpha$ , and the time cost of sex  $\tau$*
- (2) *declining in the efficacy of contraceptives  $\mu$ , the desire for sex  $\sigma^j$ , the time cost of child rearing  $\phi$ , and the weight of education in utility  $\gamma$*
- (3) *declining in female empowerment  $\theta$  if there is no gender difference in the desire for sex (for  $\sigma^F = \sigma^M$ ).*

Result (1) and (2) are obvious from inspection of (8). Result (3) inspects the derivative

$$\begin{aligned} \frac{\partial \bar{h}}{\partial \theta} &= (\sigma^M - \sigma^F) \{ [\theta\sigma^F + (1 - \theta)\sigma^M] [\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta] - (\alpha - \gamma)(1 + \delta)\tau \} / \tilde{D}^2 \\ &- [\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M] \{ (1 - \delta)\phi [\theta\sigma^F + (1 - \theta)\sigma^M] - (\sigma^M - \sigma^F) [\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta] \} / \tilde{D}^2, \end{aligned}$$

in which  $\tilde{D}$  is the denominator of (8). Increasing female empowerment reduces the threshold through increasing opportunity costs of child rearing. When there is no gender difference in the desire for sex this is the only effect on the demand of contraceptives. A gender difference for sex, taken for itself, increases the threshold since there is less sex and less need for contraceptives when female power increases. The overall impact of female empowerment on contraceptive use is thus ambiguous. Irrespective of the position of the threshold, however, female empowerment has a strong impact on the uptake of modern contraception because it leads to better education (see Proposition 5) and thus to more human capital of subsequent generations and, *ceteris paribus*, to an earlier crossing of the threshold  $\bar{h}$ .

The corner solution without use of modern contraceptives is obtained as:

$$n_t = \frac{[\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M] (1 + \delta)}{[1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M][\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta + \tau(1 + \delta)]} \quad (9a)$$

$$e_t = \frac{[\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta + \tau(1 + \delta)] \gamma h_t}{\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M} \quad (9b)$$

and consumption as in (5a). Notice that fertility and education per unit of human capital are constant. Education at the corner solution can best be conceptualized as children learning the

basic techniques of a trade or of subsistence agriculture. We call the solution at the corner the traditional equilibrium and the solution at the interior, at which modern contraceptives are used, the modern equilibrium.

It is again interesting to obtain the unilaterally optimal fertility level of husband and wife. Maximizing  $\log c_t^j + \alpha \log n_t + \gamma \log h_{t+1} + \sigma^j \log s_t$  with respect to (2)-(4) and  $u_t = 0$  provides desired fertility

$$n_t^j = \frac{(\alpha - \gamma + \sigma^j)(1 + \delta)}{[1 + \alpha + \sigma^j][\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta + \tau(1 + \delta)]} \quad (10)$$

for  $j = F, M$ . The derivative with respect to  $\sigma^j$  is now strictly positive. At the traditional equilibrium we thus observe the Darwinian result that stronger sexual desire leads to more offspring. Comparing men and women this implies the following result.

LEMMA 2. *If men desire sex more strongly than women, they prefer to have more children than women when modern contraceptives are not used.*

Combining Lemma 1 and 2 we obtain the fertility preference reversal:

PROPOSITION 3. *If men have a stronger desire for sex than women they prefer to have more children at the traditional equilibrium (when modern contraceptives are not used) and fewer children at the modern equilibrium (when modern contraceptives are used).*

Since the use of contraceptives depends on the degree of development as measured by human capital (potential income)  $h$ , an equivalent prediction is that men prefer more children than women at low levels of development and fewer children at high levels. Comparing the traditional and the modern equilibrium, we find:

PROPOSITION 4. *At the traditional equilibrium, fertility is higher and education and labor supply are lower than at the modern equilibrium.*

The proof is in the Appendix. The result is immediately intuitive by noting that the purpose of using modern contraceptives is to reduce fertility. Lower fertility sets free extra time of men and (especially) women, which leads to more labor supply and higher family income, which in turn is used to finance more consumption of husband and wife and more education of the offspring.

PROPOSITION 5. *Increasing female negotiation power  $\theta$  at the traditional equilibrium leads to less fertility and more education if women desire sex less strongly than men (for  $\sigma^F < \sigma^M$ ) or if there is wage discrimination (for  $\delta < 1$ ).*

The proof for fertility inspects the derivative

$$\begin{aligned} \frac{\partial n_t}{\partial \theta} &= - (1 - \delta)(1 + \delta)\phi [1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] [\alpha - \gamma - \theta\sigma^F + (1 - \theta)\sigma^M] / \hat{D}^2 \\ &\quad - (\sigma^M - \sigma^F)(1 + \delta) [\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta + \tau(1 + \delta)] \\ &\quad \times \{ [1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] + [\alpha - \gamma - \theta\sigma^F + (1 - \theta)\sigma^M] \} / \hat{D}^2, \end{aligned}$$

in which  $\hat{D}$  is the denominator of (9a). The proof for education is analogous. At the traditional equilibrium the impact of female empowerment on fertility is unambiguously negative because women prefer to have fewer children than men. The sex differential effect and the wage discrimination effect work in the same direction.<sup>3</sup>

### 3. LONG-RUN ECONOMIC DEVELOPMENT

Inserting (9b) into (3) we obtain the gross growth rate (growth factor) of human capital at the traditional equilibrium

$$\frac{h_{t+1}}{h_t} = g_t^T \equiv \frac{\gamma A \{ \delta\epsilon + \phi\theta + \phi(1 - \theta)\delta + \tau(1 + \delta) \}}{\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M}. \quad (11)$$

Since positive long-run growth requires a growth factor above unity we obtain the following result.

**PROPOSITION 6.** *There is positive long-run growth at the traditional equilibrium iff*

$$A > \bar{A} \equiv \frac{\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M}{\gamma \{ \delta\epsilon + \phi\theta + \phi(1 - \theta)\delta + \tau(1 + \delta) \}}$$

*The growth threshold is decreasing in the level of female empowerment  $\theta$ . If there is long-run growth, its rate  $g^T$  is increasing in female empowerment  $\theta$ .*

The proposition is verified by inspecting the derivatives of  $\bar{A}$  and  $g^T$  with respect to  $\theta$ . The result is intuitive since more female power leads to better education of the offspring (Proposition 5). Sufficiently strongly increasing female empower thus allows for an escape from stagnation and, with henceforth growing human capital, to the eventual uptake of modern contraceptives (Proposition 2), and the onset of the fertility transition (Proposition 4).

Next assume that productivity in education  $A$  is large enough such that the modern society is capable of long-run growth. Taking the limit  $h_t \rightarrow \infty$  of (5c) and inserting the result in (4) we

<sup>3</sup>In principle, there exists another corner solution when the non-negativity constraint on female labor supply binds. In order to avoid uninteresting case differentiation we assume that fertility preferences are low enough to support an interior solution.

obtain the steady-state growth rate of the modern economy

$$\frac{h_{t+1}}{h_t} = g^M \equiv \frac{\gamma A \{\delta\epsilon + \phi\theta + \phi(1-\theta)\delta\}}{\alpha - \gamma}. \quad (12)$$

Sufficiently large productivity in education  $A$  ensures that the gross growth rate exceeds unity, i.e. that there exists positive long-run growth.

PROPOSITION 7. *The modern economy grows at a higher rate than the traditional economy.*

This is verified by comparing (11) and (12). Inspection of the first order derivatives of the growth equations (11) and (12) verifies the following proposition.

PROPOSITION 8.

- *Growth at the traditional steady state is increasing in female empowerment  $\theta$  if there is wage discrimination or if men desire sex more strongly.*
- *Growth at the modern steady state is increasing in female empowerment  $\theta$  if there is wage discrimination.*

Female empowerment increases the opportunity cost of having children as long as there is wage discrimination. Via the quantity-quality trade-off this has a positive impact on education and growth at the traditional and modern equilibrium. Growth at the traditional equilibrium depends furthermore positively on empowerment because men prefer more children and less education than women. Although there is a preference reversal in fertility preferences, female empowerment does not lead to lower growth through higher fertility at the modern steady state. This is so because education is independent from gender-specific sex preferences when modern contraceptives are used (see (5c)). For equal opportunity costs of fertility, husband and wife would thus prefer the same level of education for their children. Thus, at the modern steady state, all empowerment effects on education run through the gender wage gap.

The cost and efficacy of contraceptives are irrelevant for growth at the steady state. But cost and efficacy are decisive for whether an economy is situated at the traditional equilibrium regime or at the modern equilibrium. If Proposition 2 is fulfilled, the economy is situated at the traditional equilibrium. A sufficiently strong decline of the price of contraceptives or a sufficiently high increase of its efficacy would move the economy onto the modern growth path.

The transition towards the modern economy, however, does not necessarily require an exogenous impulse. In order to make the problem interesting and to build a unified growth theory, we assume

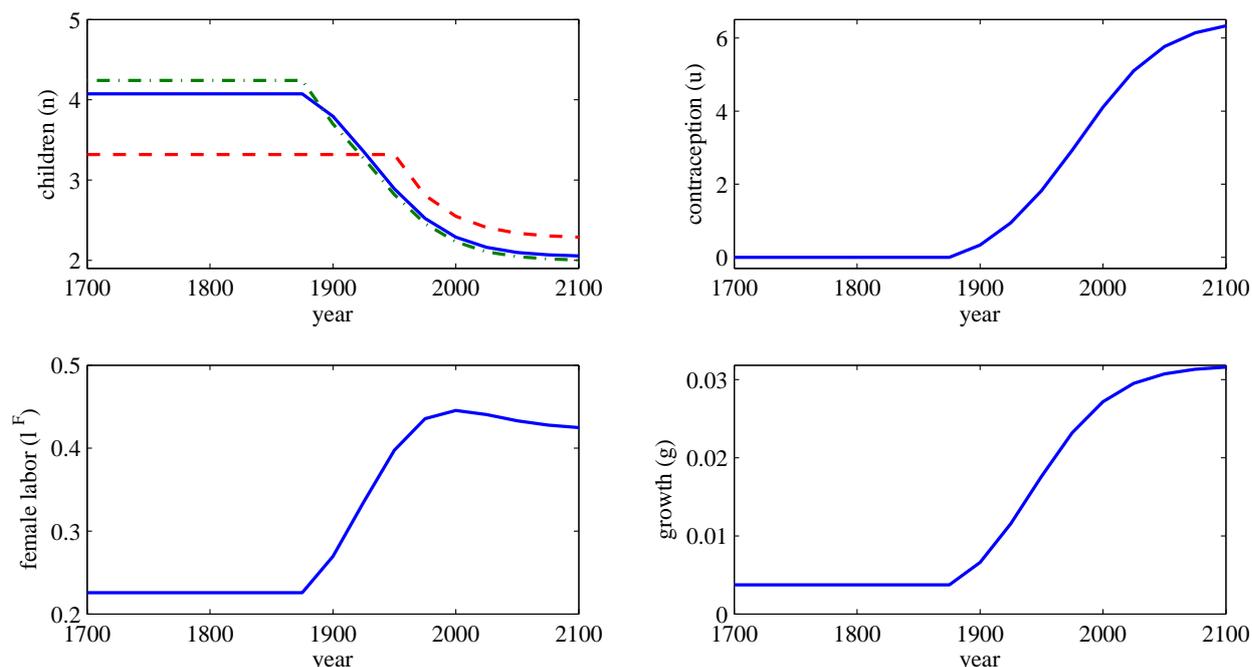
in the following that  $A$  is large enough such that the traditional economy is growing as well, albeit at a (much) smaller rate than the modern economy. This means that eventually education becomes large enough such that the threshold is crossed and the economy switches to the modern regime. The price and efficacy of contraceptives are decisive for how fast an economy transits from the traditional regime to the modern regime.

#### 4. TRANSITION TO MODERN GROWTH

We next explore transitional dynamics with a series of numerical experiments. For that purpose we set child rearing costs  $\phi$  to 0.15, according to Haveman and Wolfe (1995) and set the un-negotiable cost of child bearing  $\epsilon$  to 0.05. In the benchmark case we set the male desire for sex  $\sigma^M$  to 1 and  $\sigma^F$  to 1/2. We set  $\delta = 0.45$  and  $\theta = 0.2$ . This implies that women supply about 20 percent of the time for wage work, a value which corresponds with the female labor force participation rate at the dawn of the historical fertility transition in the West (Goldin, 2014). Evolving  $\theta$  and  $\delta$  will be discussed in the next section. We set  $\tau = 0.02$  and determine the remaining parameters such that the modern economy grows at an annual rate of about 2 percent in the late 20th century, such that the traditional economy grows at a rate of 0.3 percent, and such that fertility approaches replacement level as the economy converges towards the modern steady state. This provides the estimates  $\alpha = 2$ ,  $\gamma = 1.41$ , and  $A = 8.3$ .

As shown above, price and efficacy of contraceptives do not affect the steady state. We use the data in Table 2 of Greenwood and Guner (2010) to obtain a first estimate of  $\mu$ . For this purpose, we assume that the traditional method consists of an average of no contraception at all (failure rate 0.85 percent) and withdrawal (failure rate 0.225), providing a failure rate of the traditional method of 0.53. For the effectiveness of condoms, we use an average between rubber condoms (failure rate 0.45) and latex condoms, which became available in the 1920s (failure rate 0.175). This provides a failure rate of 0.31, and an estimate of  $\mu = (1 - 0.31)/(1 - 0.53) = 1.46$ . Finally we set the initial time to the year 1400 and the initial endowment  $h(0)$  to 10. We then determine  $p$  such that modern contraceptives are used for the first time in 1900, i.e. with a delay of two generations after the invention of vulcanized rubber (patented in 1844) and the introduction of the rubber condom. This provides the estimate  $p = 4.2$ . After running the numerical experiments, we convert the measure of every variable from per-generation to per-year in order to facilitate comparison with the real evolution of these variables. For this purpose we assume that a generation takes 25 years.

Figure 2: Long-Run Adjustment Dynamics: Basic Model

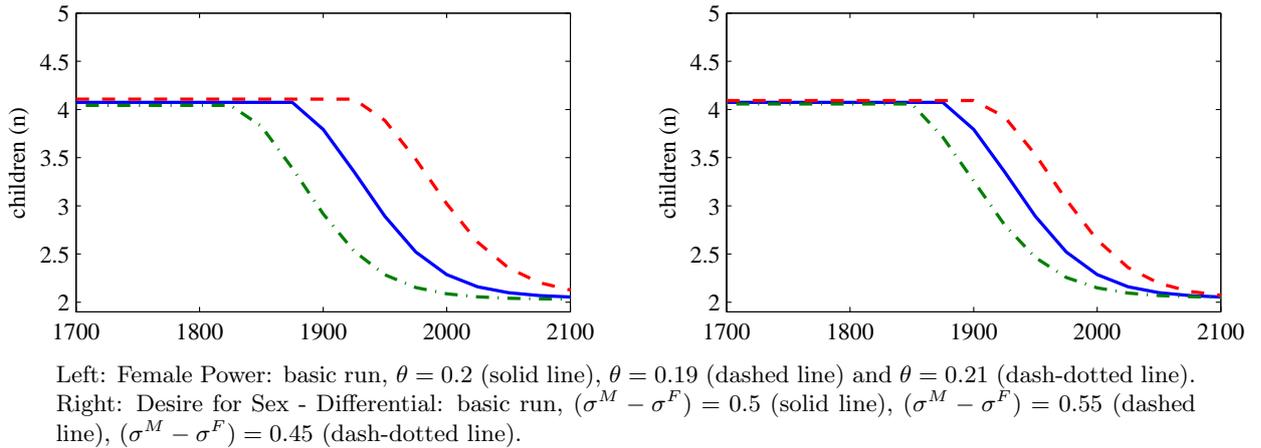


Top left panel: fertility  $n_t$  (solid line) and desired fertility by women (dashed line) and men (dash-dotted line).

Figure 1 shows the implied development. The upper left panel shows the evolution of actual and desired fertility. Before the onset of contraceptive use, fertility desired by men (dash-dotted line) slightly exceeds actual fertility (solid line) while women's desired fertility (dashed line) lies markedly below actual fertility. The male-female fertility differential is 0.92 and coincides roughly with the average fertility differential of 1.0 for the DHS sample of Figure 1. After the onset of contraceptive use in 1900, fertility declines and the desired fertility of women exceeds that of men and the distance both rates declines. At the end of the demographic transition, in the year 2000, the male-female fertility differential declines to -0.28. The fertility transition is accompanied by a take off of growth of human capital (and thus per capita income) and by an increase in female labor supply. At the end of the transition the model predicts, counterfactually, an overshooting of female labor supply because fertility adjusts somewhat faster to its steady state level than the time that the couple spends on sex. This phenomenon disappears in the extended version of the model (see Section 5).

We next look at the quantitative impact of gender power and the desire for sex and resolve, for the numerical example, the remaining ambiguities from the theory part. The panel on the left hand side of Figure 3 shows results for alternative values of  $\theta$ . The solid line reiterates the benchmark

Figure 3: Long-Run Adjustment Dynamics: Sensitivity Analysis



case from Figure 2. The dashed lines shows results for  $\theta = 0.21$  and the dash-dotted line shows results for  $\theta = 0.19$ . The figure suggests a strong dynamic effect of female empowerment through education. When  $\theta$  rises from 0.19 to 0.21 the threshold  $\bar{h}$  declines only slightly by about one percent (which does, taken for itself, not change the onset of the fertility transition). However, the threshold is reached much earlier through the impact of female power on education and growth of human capital. As a consequence, a two percentage point difference in  $\theta$  motivates about a century delay of the fertility transition.

The panel on the right hand side of Figure 3 shows adjustment dynamics for alternative values of the desire-for-sex differential between men and women. The solid line reiterates the basic case. Dashed lines show results when the sex differential is 5 percent greater (because females desire sex less strongly). Dash-dotted lines show the case when the sex differential is 5 percent smaller. Again, the threshold  $\bar{h}$  remains almost invariant to the change in  $\sigma^F$ . The onset of the fertility transition is delayed predominantly because fertility is higher and closer to the men’s ideal rate when women desire more sex, which leads to reduced education and human capital growth at the traditional equilibrium (but not at the modern equilibrium).

## 5. EXTENSIONS

**5.1. Endogenous Empowerment.** In this section I add more realism to the model by endogenizing female empowerment  $\theta$  and the gender gap  $\delta$ . A plausible and empirically supported assumption is that female power in household decisions depends positively on the relative income that the wife contributes to household income (Basu, 2006; Rahman and Rao, 2005; Anderson and Eswaran,

2009). A reasonable benchmark is that spousal power equalizes for equal contributions to household income. If contemporaneous bargaining power is determined by the contemporaneous income gap, there exist potentially multiple coordination equilibria. In order to avoid this additional complication, I assume that contemporaneous bargaining power depends on last period's income gap, such that  $\theta$  is a pre-determined dynamic variable, captured by the formula  $\theta_{t+1} = 0.5(y_t^F/y_t^M)^\beta$ . The parameter  $\beta$  controls how quickly female empowerment adjusts with narrowing income gap  $y_t^F/y_t^M$ . The delayed adjustment of bargaining power can be motivated by arguing that the contemporaneous income gap resulting *after* problem (1)–(4) has been solved reflects the power distribution in the household observed by male and female children and internalized by them to determine their power when they become adults and spouses.

The gender income gap in turn is determined by the wage gap  $\delta_t$  and gender-specific labor supply,  $y_t^F/y_t^M = \delta_t \ell_t^F/\ell_t^M$ . Inserting labor supply of the spouses we obtain

$$\theta_{t+1} = \frac{1}{2} \left( \frac{\delta_t [1 - \epsilon n_t - (1 - \theta_t)\phi n_t]}{1 - \theta_t \phi n_t} \right)^\beta \quad (13)$$

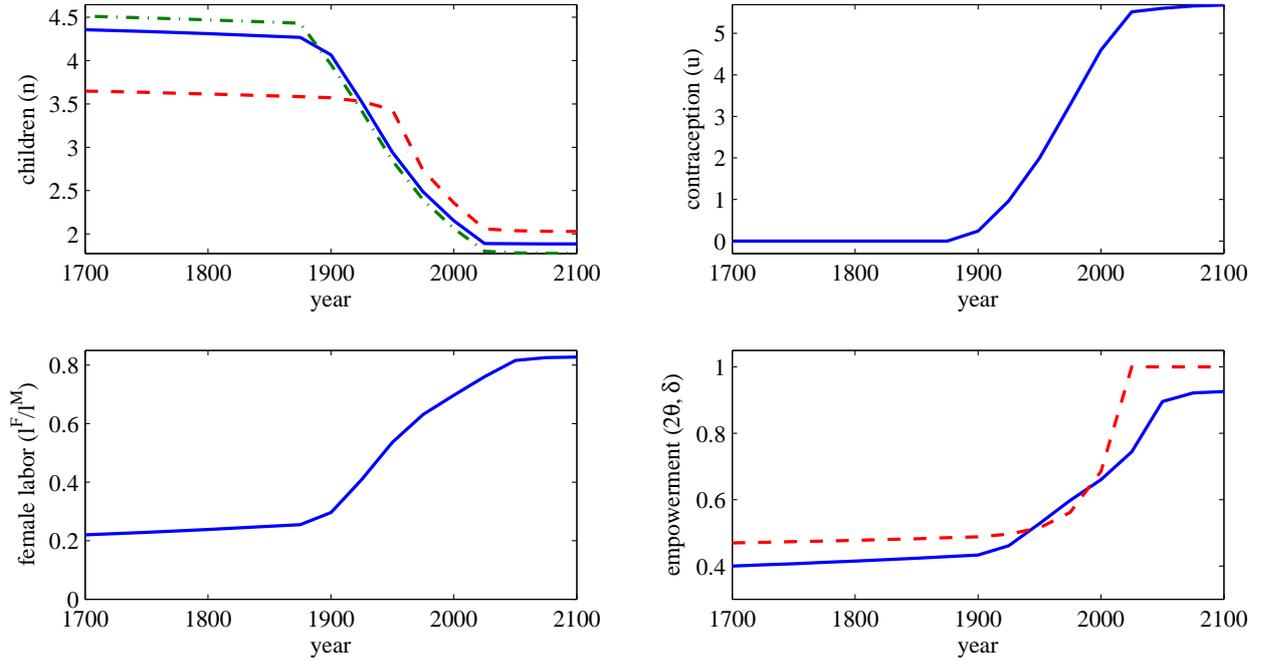
Furthermore, I endogenize the gender wage gap such that it is declining with economic development, in line with the stylized facts (Goldin, 2014). For this purpose, I assume that  $\delta_t$  is declining in average human capital, reflecting, for example, the comparative advantage of women in skill-intensive occupations (as in Galor and Weil, 1996) or a more general positive impact of education on the appreciation of equality and women's rights. A parsimonious way to implement these ideas is the following formula:

$$\delta_t = \min \{1, \delta_0 + \delta' h_t\}, \quad (14)$$

and  $\delta_0, \delta' > 0$ . In (14) we have assumed that the gender wage gap disappears when human capital gets sufficiently large. Gender power  $\theta$  nevertheless remains unequal as long as some female child bearing and rearing tasks are non negotiable (as long  $\epsilon$  is positive). Putting  $\delta_t$  to unity in (13) we see that the solution converges to  $\theta = 1/2$  for  $\epsilon = 0$  and to some smaller value of  $\theta$  for  $\epsilon > 0$ .

The take up of contraceptives increases female bargaining power. This is verified from (13) by evaluating  $\partial\theta_{t+1}/\partial n_t = -[e + \phi(1 - 2\theta)]/[2(1 - \theta\phi n_t)^2] < 0$ , because  $\theta \leq 1/2$ . Intuitively, lower fertility reduces female rearing time by more than male rearing time as long as  $\theta < 1/2$ , i.e. as long as there is gender power inequality. This in turn raises female labor supply more than male labor supply. It reduces the income gap and increases female bargaining power.

Figure 4: Long-Run Adjustment Dynamics: Endogenous Bargaining Power



Top left panel: fertility  $n_t$  (solid line) and desired fertility by women (dashed line) and men (dash-dotted line). Bottom right panel: empowerment,  $2\theta$  (solid line), gender wage gap  $\delta$  (dashed line).

In order to approximate the historical evolution of female labor supply in the U.S. (Goldin, 2008), I set  $\delta_0 = 0.2$  and  $\delta' = 0.0008$ . I set  $\beta = 0.4$  in order to obtain a female/male labor force participation of about 20 percent at the dawn of the fertility transition (Goldin, 2008). I take all parameter values from the benchmark model aside from adjusting  $\gamma$  to 0.13 in order to get about the same fertility rate in the year 2000 as the benchmark model and aside from adjusting  $A$  to 10 in order to enable the economy to grow at the traditional equilibrium.

The resulting adjustment dynamics are shown in Figure 4. In contrast to the benchmark case, female labor participation is already (mildly) increasing before the uptake of contraceptive use because of gradually increasing human capital and a gradually declining gender wage gap (dotted line, lower right panel) at the traditional equilibrium. The take-off to growth, however, still occurs with the uptake of modern contraceptives. In line with the historical evidence the model predicts that female labor force participation starts to increase in the early 20th century whereas much of the gender wage gap closes only in the late 20th century (Goldin, 2008). For the year 2000 the model predicts about the actual U.S. female labor participation rate (70 percent) and about the actual wage gap (70 percent). Otherwise, the extension preserves the results from the basic model. The main difference to the basic model is that the predicted time of the fertility transition is now

much shorter because of the amplifying effects from increasing female power and declining gender wage discrimination.

**5.2. Gender-biased Education.** For most of the span of the historical fertility transition of the West, girls received on average less education than boys (Goldin, 2008) and, although much progress has been made, female higher education is still lacking behind in many contemporaneous developing countries (United Nations, 2013). In this section I thus check robustness of results against the introduction of a gender bias in education. For this purpose, I follow Lagerloef (2003) by assuming that spouses are no longer interested in only the human capital of their own children but also in the human capital (i.e. potential income) of the family with which their children end up with as adults. The fact that parents cannot control the human capital of their offspring's future spouses creates an externality and causes the optimal solution for the division of schooling expenses among sons and daughters to be indeterminate. This feature makes Lagerloef's approach not only very general, because the ultimate driver of the gender bias remains unspecified, but also formally much easier to implement than other approaches to gender inequality in education.

Consider a family in which half of the offspring are girls and boys, respectively and assume that the spouses do not discriminate against boys and girls. Specifically, let the former utility weight of human capital per child ( $\gamma$ ) be equally divided on human capital in the future households of sons and daughters. This means that utility function (1) is replaced by

$$V = (1 - \theta) \log c_t^M + \theta c_t^F + \alpha \log n_t + \sigma^F + [(1 - \theta)\sigma^M + \theta\sigma^F] \log s_t + \frac{\gamma}{2} \log(h_{t+1}^M + \bar{h}_{t+1}^F) + \frac{\gamma}{2} \log(\bar{h}_{t+1}^M + h_{t+1}^F) \quad (15)$$

in which  $h_{t+1}^M$  and  $h_{t+1}^F$  denote the human capital of their male and female offspring and  $\bar{h}_{t+1}^M$  and  $\bar{h}_{t+1}^F$  denote the expected human capital of their offspring's future spouses.

Taking gender-specific education expenditure into account the household's budget constraint (2) modifies to

$$h_t^F [1 - en_t - (1 - \theta)\phi n_t - \tau s_t] + h_t^M [1 - \theta\phi - \tau s_t] = c_t^F + c_t^M + e_t^M \frac{n_t}{2} + e_t^F \frac{n}{2} + p_t u_t. \quad (16)$$

As before, human capital is produced linearly from education expenditure

$$h_{t+1}^j = A e_t^j, \quad j = M, F. \quad (17)$$

Households maximize (15) s.t. (3), (16), and (17), which leads, inter alia to the first order conditions for male and female education,

$$\frac{\gamma}{2} \frac{1}{e_t^M + \bar{e}_t^F} - \frac{\lambda}{2} = 0, \quad \frac{\gamma}{2} \frac{1}{\bar{e}_t^M + e_t^F} - \frac{\lambda}{2} = 0, \quad (18)$$

in which  $\bar{e}_t^j$ ,  $j = M, F$ , is the expected education of their children's future spouses and  $\lambda$  is the shadow price of consumption. Condition (18) reveals the crucial externality: Ceteris paribus, households invest less in the education of their daughters when they expect that other households investment more in the education of boys.<sup>4</sup> By assumption, however, households are symmetric. Inserting  $e_t^j = \bar{e}_t^j$  into the first order conditions and solving the complete household problem leads to the interior solution:

$$n_t = \frac{(\alpha - \gamma)(h_t^M + \delta h_t^F)\mu}{[1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] \{ \mu\epsilon\delta h_t^F + \mu\phi [(1 - \theta)\sigma^M h_t^M + \theta\sigma^F \delta h_t^F] - p \}} \quad (19a)$$

$$e_t = \frac{\gamma \{ \mu\epsilon\delta h_t^F + \mu\phi [(1 - \theta)\sigma^M h_t^M + \theta\sigma^F \delta h_t^F] - p \}}{(\alpha - \gamma)\pi_t\mu} \quad (19b)$$

$$u_t = \left( \frac{\theta\sigma^F + (1 - \theta)\sigma^M}{\mu\tau(h_t^M + \delta h_t^F) + p} - \frac{\alpha - \gamma}{\mu\epsilon\delta h_t^F + \mu\phi [(1 - \theta)\sigma^M h_t^M + \theta\sigma^F \delta h_t^F] - p} \right) \frac{(h_t^M + \delta h_t^F)}{1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M}.$$

For  $h_t^M = h_t^F$  the solution (21) boils down to (5). In contrast to the simple model, however, the division of total education expenditure  $e_t$  among sons and daughters is indeterminate. The corner solution without use of moderns contraceptives is obtained as

$$n_t = \frac{[\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M] (h_t^M + \delta h_t^F)}{[1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] \{ \epsilon\delta h_t^F + \phi [(1 - \theta)\sigma^M h_t^M + \theta\sigma^F \delta h_t^F] + \tau(h_t^M + \delta h_t^F) \}} \quad (20a)$$

$$e_t = \frac{\gamma \{ \epsilon\delta h_t^F + \phi [(1 - \theta)\sigma^M h_t^M + \theta\sigma^F \delta h_t^F] + \tau(h_t^M + \delta h_t^F) \}}{\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M} \quad (20b)$$

**PROPOSITION 9.** *At both the modern and traditional equilibrium, better education of fathers increases total education expenditure of the family. Better education of fathers increases fertility at the traditional equilibrium and decreases fertility at the modern equilibrium if the wife's contribution to family income is sufficiently low, i.e. if  $\mu\delta h_t^F < p/[\epsilon + \phi(1 - 2\theta)]$ . Better education of mothers always reduces fertility and increases education of the offspring.*

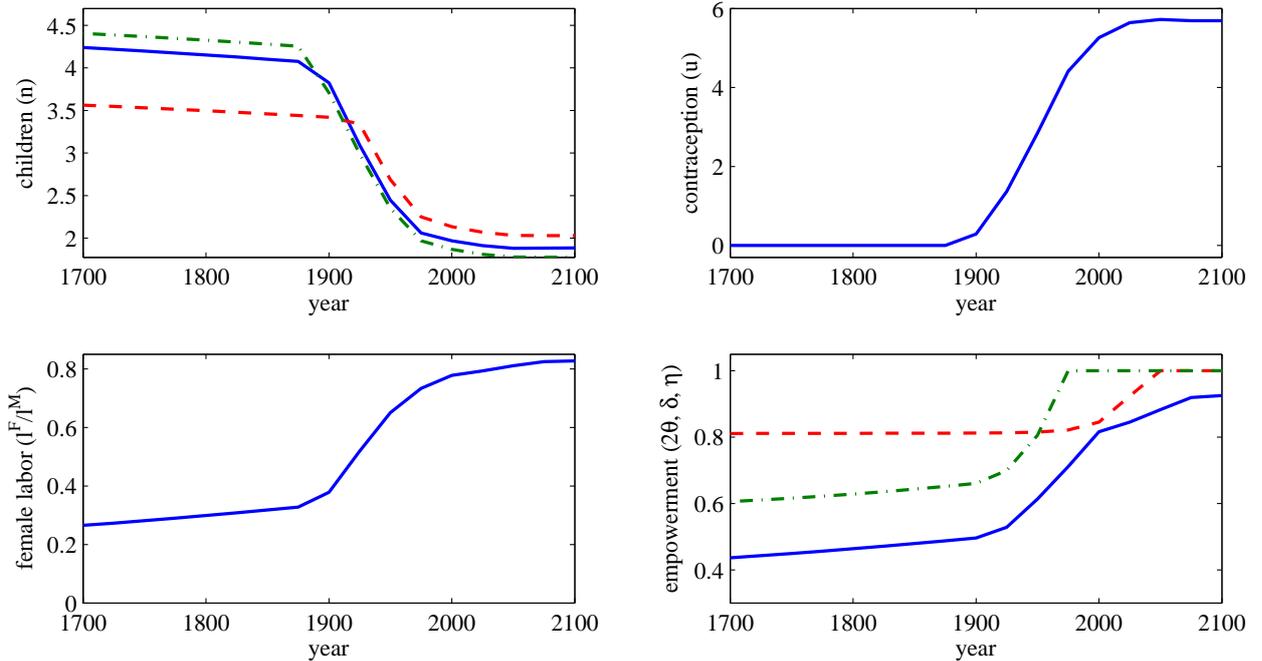
<sup>4</sup>Of course, in theory, this holds also the other way round, but inferior investment in girl's education is, in practice, the relevant case.

The proof inspects the derivatives of  $e_t$  in (19b) and (20b) with respect to  $h_t^M$  and  $h_t^F$  and observes that they are unambiguously positive. It inspects the derivatives of  $n_t$  in (20a) with respect to  $h_t^M$  and  $h_t^F$  and observes that the sign is determined by the sign of  $\epsilon + \phi(1 - 2\theta)$ , which is always positive since  $\theta \leq 1/2$ . Finally it inspects the derivative of  $n_t$  in (19a) and observes that the sign is determined by the sign of  $-[p + h_t^M \mu(\epsilon + \phi(1 - \theta))]$  when the derivative is taken with respect to  $h_t^F$ , and is thus always positive, and that the sign is determined by  $-[p - h_t^F \mu(\epsilon + \phi(1 - \theta))]$  when the derivative is taken with respect to  $h_t^M$ , which is negative when the condition of Proposition 9 is fulfilled.

The result clarifies that the education of both father and mother are conducive to the schooling of sons and/or daughters and the use of contraceptives. Moreover, better educated fathers want to have less children when the couple uses modern contraceptives and female contribution to family income is sufficiently low. The latter result is intuitive when one considers the special case in which mothers contribute nothing to family income and the couple prefers to use modern contraceptives. In this case higher fertility harms family income only through the (small but) increasing child rearing time of the father such that rising income of fathers unambiguously increases the opportunity costs of fertility and thus leads to less fertility. Only if fathers contribute nothing to child rearing the derivative of  $n_t$  with respect to  $h_t$  turns positive. This results explain why studies focussing on the education of spouses may have difficulties in identifying a positive impact of female empowerment. Here, the theory disentangles the effects and finds that increasing female power  $\theta$  exerts independently a positive influence on education and (at the traditional equilibrium) a negative influence on fertility when education of spouses is held constant (see Proposition 1 and 5 still hold true for the extended model).

Since the gender education gap is indeterminate within the model, it is determined by the environment outside the model. The most plausible assumption is that it is shaped by culture, i.e. by attitudes and beliefs on the desirability of female education. Strulik (2013) provides a micro-founded model of norm evolution, child labor and education. Here, I implement for simplicity a “reduced form”, based on the idea that level of male education effects a family’s attitudes towards gender-specific education. The reduced form could capture the notion that increasing knowledge reduces traditional believes in gender roles and leads to a higher appreciation of education as a value in itself. Alternatively, it could capture the notion that better educated fathers develop a

Figure 5: Long-Run Adjustment Dynamics: Gender Education Bias



Top left panel: fertility  $n_t$  (solid line) and desired fertility by women (dashed line) and men (dash-dotted line). Bottom right panel: empowerment,  $2\theta$  (solid line), gender wage gap  $\delta$  (dashed line), female-male education ration (dash-dotted line).

higher interest in the wellbeing of their daughters (Doepke and Tertilt, 2009).<sup>5</sup> A parsimonious formulation for the evolution of  $e_t^F/e_t^M \equiv \eta_t$  is

$$\eta_t = \min \{1, \eta_0 + \eta' h_t\}. \quad (21)$$

The introduction of an education bias allows us to disentangle the effects of education and discrimination on the gender bias in earnings. For the calibration I set  $\eta_0 = 0.55$  and  $\eta' = 0.006$  in order to approximate the historical evolution of the gender gap in education in the U.S. and I adjust  $\delta = 0.81$  and  $\delta' = 0.00005$ . The implied development is shown in Figure 5. The parametrization of the model implies a closure of the education gap by about the 1970s, in line with the stylized facts (Goldin, 1999).

The extension allows to disentangle the effects from education and wage discrimination on female earning and thus female power in the family. Compared to the case of Figure 4, a similar path of female negotiation power is supported by a much lower degree of wage discrimination, as shown by the dashed line in the lower right panel of Figure 5. The dash-dotted line in the same panel

<sup>5</sup>In Lagerloef's (2003) original contribution, applied to the demographic history of Europe, the education gap is assumed to be a function of calendar time. This approach is less suitable here since it prevents the discussion of cross-country differences in attitudes towards female education.

shows the evolution of the education gap, which closes rapidly during the first half of the 20th century. Nevertheless, in line with the stylized facts (Goldin, 2008), a gender gap in earnings per time unit of work remains due to the delayed adjustment of wage discrimination. Otherwise the adjustment trajectories are similar to the ones shown in Figure 4. The education bias allows also for a different mechanism determining female power in the household. It has been argued (Pollak, 2005) that female education is a better proxy for power in the household because it better captures the wife's outside option (threat point). As a numerical experiment I thus replaced (13) by  $\theta_{t+1} = (h_t^F/h_t^M)^\beta/2$  and arrived at similar development dynamics as shown in Figure 5.

APPENDIX

**Proof of Proposition 4.** From Proposition 2 we have that fertility at the modern equilibrium fulfills

$$p [\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M] < \{ [\theta\sigma^F + (1 - \theta)\sigma^M] [\phi + (1 - \theta)\phi\delta + \epsilon\delta] - (\alpha - \gamma)\tau(1 + \delta) \} \mu h_t,$$

that is

$$[\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M] [\phi + (1 - \theta)\phi\delta + \epsilon\delta - p] > (\alpha - \gamma)\mu h [\delta\epsilon + \phi\theta + (1 - \theta)\delta + \tau(1 + \delta)],$$

that is

$$\begin{aligned} LHS < RHS, \quad LHS &\equiv \frac{(\alpha - \gamma)(1 + \delta)\mu h_t}{[1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] \{ \mu\epsilon\delta + \mu\phi [\theta\sigma^F + (1 - \theta)\sigma^M] - p \}} \\ RHS &\equiv \frac{[\alpha - \gamma + \theta\sigma^F + (1 - \theta)\sigma^M] (1 + \delta)}{[1 + \alpha + \theta\sigma^F + (1 - \theta)\sigma^M] [\phi\theta + \phi(1 - \theta)\delta + \epsilon\delta + \tau(1 + \delta)]}. \end{aligned}$$

The left hand side of the above inequality is fertility at the interior equilibrium (5b) and the right hand side is fertility at the corner (9a).

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