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DESIRE AND DEVELOPMENT

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Abstract. This paper explores the impact of gender differences in the desire for sex and the distribution of power in the household on 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 economy assumes one of two possible equilibria. 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 a "wanted fertility reversal": At the traditional equilibrium, men prefer more children than women whereas at the modern equilibrium, men prefer fewer children than women. Female empowerment nudges households to provide more education for their children and leads to an earlier uptake of modern contraceptives and 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.

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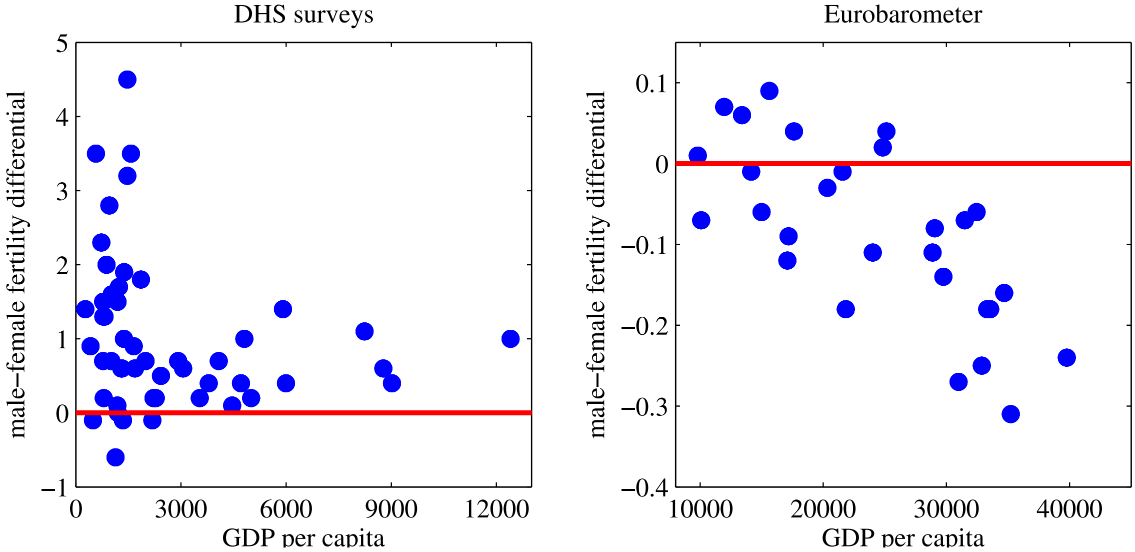
1. Introduction

Humans like to have sex. While most readers may regard this insight as obvious, the economics literature also provides supporting evidence that sex is a utility enhancing activity (Blanchflower and Oswald, 2004). This appears to be true for both 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, 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 as 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 have less desire to have sex than men.

The model predicts a reversal of gender-specific preferences in the wanted fertility level. 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 of 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,

Figure 1: Preferred Fertility: Male – Female (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 male and mean female 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., 2015.

however, there is a tight link between sexual intercourse and fertility, and men prefer to have more children than women due to their stronger desire for sex.

Figure 1 illustrates the reversal of wanted fertility 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 DHS surveys (ICF, 2012) whereby in case of multiple surveys for a country, only the most recent survey is 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. (2015). 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 percent among married women). In most countries, 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, 25,700 international Dollars), education levels are high, and fertility is so low that in many countries it is below the replacement level (the average wanted 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.[1]

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.[2] 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), education (Lagerloef, 2003; Hazan and Zoabi, 2013; Hiller, 2014; Doepke and Tertile, 2014), and child rearing costs (de la Croix and Vander Donckt, 2010). Similar to the present study, Prettner and Strulik (2014a) suggest that the onset and speed of demographic transition is essentially affected by female empowerment if (and only if) men prefer to have more children than women. There, however, the gender differential in child preferences is assumed rather than derived and the human desire for sex and the use of contraception are not considered. 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 have remained unexplored in the available literature. Like Strulik (2016), Bhattacharya and Chakraborty (2016) investigate the role of contraceptives for development when decisions are made by a unitary household but they neglect a utility enhancing motive for sexual intercourse. Prettner and Strulik (2014b) investigate the role of traditional religion for contraceptive use and its impact on the

[1] There are, of course, other complementing mechanisms explaining why women prefer fewer children than men at low levels of economic 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).

[2] 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.

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 macroeconomic studies focus on the impact of gender-biased education or wages. There exists, however, empirical support from microeconomic studies on the association between various measures of female empowerment and contraception and fertility (see e.g. Dyson and Moore, 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 a negative impact on fertility and a positive impact on education and income of subsequent generations. With respect to developing countries, many demographers regard contraceptive use 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).

Promoting gender equality and empowering women is an important part of the United Nations "Millennium Development Goal". A contested issue, however, is whether "the empowerment and autonomy of women ... is essential for the achievement of sustainable development" (United Nations, 1995, p. 194) or whether development progresses without female empowerment (which should then be pursued for its own sake). Duflo (2012) reviews the *microeconomic* evidence and argues that the economic responses to female empowerment are probably too weak to initiate a self-sustained process of economic development and further rising female power. Here, I propose a somewhat more optimistic outlook based on the potential *macroeconomic* consequences of female empowerment. Specifically, I show that female empowerment nudges households towards more education and through this channel to an earlier uptake of modern contraceptives, which induces an earlier onset of the demographic transition. 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 or (in the case of stagnation of the traditional economy) essential determinant of development.

The paper is organized is follows. The next section presents 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 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. Furthermore, section 5 introduces, inspired by Lagerloef (2003), an endogenous gender bias in education. Section 6 concludes.[3]

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 δ 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 θ, $0 \leq \theta \leq 1/2$. 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 is assigned to females or males. Variables without a superscript are shared by men and women. In order to avoid confusion, I refer to the biological sex of men and women as "gender" and use "sex" as shorthand for sexual intercourse.

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 ℓ_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 δ 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.

[3]In Strulik (2016), I discuss several extensions and robustness checks for the unitarian household model of contraceptive use. I consider child mortality, diffusion of contraceptive use in a society stratified by income and education, and endogenous technological change in the efficacy of contraceptives. I also quantitatively evaluate the importance of contraception in the unified growth model of Galor and Weil (2000). For the sake of brevity and in order to focus on the role of gender-specific preferences and bargaining power, I do not re-investigate these extensions in the present context. In Strulik (2016), I provide a detailed discussion of the role of contraceptives in the historical fertility transition of the West and its impact on the increase of sexual activity in marriage during the 20th century.

Adults experience utility from consumption, from having children, from their children's human capital (their 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 without implications for the results. For simplicity, we neglect infant and child mortality. Moreover, in the basic model, we assume that there is no gender bias in education and we rule out gender-specific birth control such that half of all offspring are boys and girls, respectively. In order to derive an analytical solution, utility functions are assumed to be separable and logarithmic. This means that the household maximizes

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

The weights α, γ, and σ^j identify the relative importance of children, education, and sex in utility. We assume $\gamma < \alpha$, which ensures that individuals 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 $\sigma^M \geq \sigma^F$, that is, we assume that men like sex no less than women and potentially much more. Notice that the preference for sex is the only potential difference between male and female utility. This is the minimal setup required in order to focus on this particular issue. Any gender differences in wanted fertility and education are thus endogenously derived and not imposed at the outset.[4]

In this model, men and women are each 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 be denoted by ϵ, $\epsilon \geq 0$. How the remainder of the time cost of child rearing, denoted by ϕ, is distributed among husband and wife depends on the degree of empowerment. Powerless women bear the burden of child-rearing alone whereas for couples with equal balance of power, child rearing duties are also distributed equally. This means that women spend a total time of $\epsilon + (1-\theta)\phi$ on child rearing per child and men spend $\theta\phi$.[5] Assuming a time cost of sex, denoted

[4] See Prettner and Strulik (2014a) for a discussion of female empowerment in a similar unified-growth context when men and women have dissenting preferences with respect to child education and fertility (and abstracting from the desire for sex and contraceptive use).

[5] Alternatively, one could also allow households to bargain over child rearing. For the case without use of modern contraceptives it can be shown that this approach leads to a structurally identical solution for fertility and education

by τ, prevents sexual activity from limitlessly increasing in a growing economy. Alternatively, we could use a satiation level or a physical upper limit for sex without changing the results. In short, the household's budget constraint is given by

$$h_t^M\left[1-\theta\phi n_t-\tau s_t\right]+\delta h_t^F\left[1-\epsilon n_t-(1-\theta)\phi n_t-\tau s_t\right]=c_t^F+c_t^M+e_t n_t+p_t u_t \tag{2}$$

in which e_t is investment in (formal) education. This formulation assumes that education is performed outside the household, at school. Outsourcing education avoids the discussion of 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 considered 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 μ controls for the effectiveness of modern contraceptives. A unit of modern contraceptives prevents the birth of μ children. Taking the corner solution into account, the number of births is

$$n_t=\min\left\{s_t-\mu u_t,\,\bar{n}\right\}, \tag{3}$$

in which u_t is household demand for modern contraceptives.[6]

Human capital is produced according to the production function

$$h_{t+1}^j=Ae_t^j, \tag{4}$$

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 Appendix B, I show results for a model version with decreasing returns to 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 are $c_t^F=\theta c_t$,

and gender-specific child-rearing effort that depends linearly on bargaining power. For the case with contraceptive use, there exists no closed-form solution. Here, we thus follow a "reduced-form" approach, for which a closed-form solution exists.

[6]See Cinnirella et al. (2012) for evidence of birth control within marriage and fertility below fecundity level in pre-industrial England.

$c_t^M = (1-\theta)c_t$, and

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

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

$$e_t = \frac{\gamma\left\{\mu\epsilon\delta+\mu\phi\left[\theta+(1-\theta)\delta\right]h_t-p\right\}}{(\alpha-\gamma)\mu} \tag{5c}$$

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

Notice that contraceptive effort μu_t assumes a finite value for $\mu \to \infty$. Furthermore, the price of contraception plays asymptotically no role for the fertility and education decision if human capital (income) approaches infinity (for $h \to \infty$). For finite income, the introduction of sexual desire and contraceptive use provides a "natural" explanation for the negative association between income and fertility. Rising income (better education) reduces the relative price of modern contraception, p/h, and thus induces more contraceptive use.[7]

For comparison, it is interesting to compute the 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 wanted fertility

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

for $j = F, M$. Taking the derivative with respect to σ^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 using modern contraceptives.*

This, perhaps surprising, non-Darwinian result reflects the impact of contraceptives. When individuals have a strong desire for sex, 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 possess a stronger desire for sex.

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

[7]See Jones et al. (2010) for a discussion on the difficulties in explaining the negative income-fertility nexus of the standard economic model of fertility choice

Proposition 1. *Increasing female negotiation power θ*

(1) *leads to better education e_t if there is wage discrimination (for $\delta < 1$),*

(2) *leads to more consumption by both partners c_t if men desire sex more strongly (for $\sigma^M > \sigma^F$), and*

(3) *has a generally ambiguous effect on fertility. It leads to raising fertility levels if there is no wage discrimination and men prefer sex more strongly. It leads to less fertility if there is wage discrimination and no gender difference in sexual desires.*

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

$$\frac{\partial n_t}{\partial \theta} = \frac{(\alpha-\gamma)(1+\delta)\mu h^2 \left\{(\sigma^M - \sigma^F)\left[\epsilon\mu\delta + \phi\mu(1-\theta)\delta + \phi\mu\theta\right] - (1-\delta)\mu\phi\left[1+\alpha+\theta\sigma^F + (1-\theta)\sigma^M\right]\right\}}{D^2}, \tag{7}$$

in which D is the denominator of (5b). Observe that the first term in curly parentheses is positive for $\sigma^M > \sigma^F$ and that the second term is negative for $\delta < 1$. The second term reflects the conventional child quality-quantity trade-off. When (less paid) women spend less time child-rearing, family income declines and the opportunity cost of having children increases, which leads to less fertility and more education. Recalling Lemma 1, the positive impact through the first term is also intuitive. The negotiated fertility level of the family rises with increasing female empowerment since men prefer to have fewer children than women when they face a higher desire for sex, . 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*

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

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

(1) *increasing in the price of contraceptives p, the weight of children in utility α, and the time cost of sex τ,*

(2) *declining in the efficacy of contraceptives μ, the desire for sex σ^j, the time cost of child rearing ϕ, and the weight of education in utility γ, and*

(3) *declining in female empowerment θ 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

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

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 for contraceptives. If there is a gender differential for sex, there are two additional effects: On the one hand, women prefer less sex, which reduces the demand for contraceptives and thus increases the threshold for its uptake (substitution effect). On the other hand, disposable income rises when the couple spends less time having sex, which increases the demand for contraceptives and thus lowers the threshold (income effect). 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:

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

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

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, i.e. when 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 wanted fertility

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

for $j = F, M$. The derivative with respect to σ^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 in this context 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 "Reversal of Desired Fertility":

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 frees extra time for men and (especially) women, which leads to more labor supply and higher family income, which in turn is used to finance greater consumption and more education of the offspring.

PROPOSITION 5. *Increasing female negotiation power θ 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 with respect to the fertility level inspects the derivative

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

in which $\hat{D}$ is the denominator of (9a). The proof with respect to 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.[8]

3. Long-Run Economic Development

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

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

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 if*

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

The growth threshold $\bar{A}$ is decreasing in the level of female empowerment θ.

The proposition is verified by inspecting the derivatives of $\bar{A}$ and g^T with respect to θ. The result is intuitive since more female power leads to better education of the offspring (Proposition 5). Sufficiently strongly increasing female empowerment 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 $h_t \to \infty$ of (5c) and inserting the result in (4) we obtain the steady-state growth rate of the modern economy

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

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

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

[8] 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 positive (yet potentially very small) female labor supply.

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

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

Growth at the modern equilibrium is independent from the sex drive of individuals. Growth at the traditional equilibrium, in contrast, exhibits the Darwinian–Malthusian feature of being negatively affected by the sex drive (and thus fertility). Likewise, the cost and efficacy of contraceptives are irrelevant for growth at the modern steady state. At the same time, cost and efficacy of contraceptives 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 in 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 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 education levels eventually become 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 a traditional to a modern regime.

4. Transition to Modern Growth

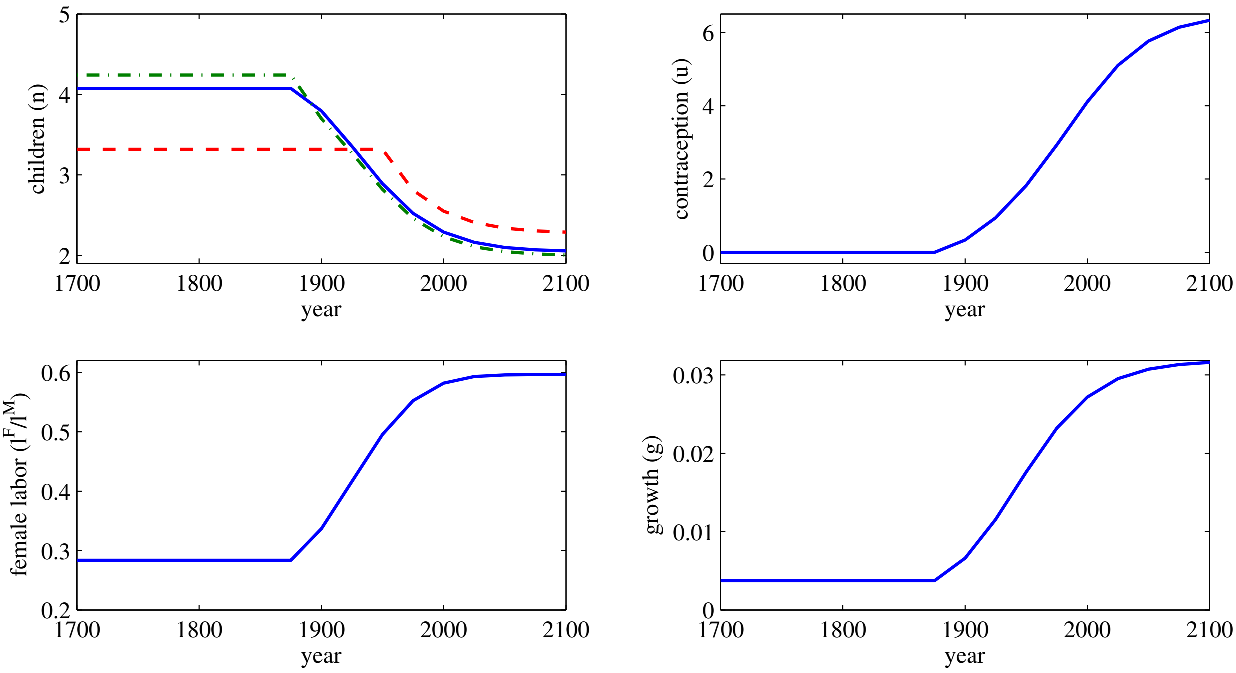
We next explore transitional dynamics with a series of numerical experiments. To do this, we set child-rearing costs ϕ to 0.15, according to Haveman and Wolfe (1995) and set the un-negotiable cost of child-bearing ϵ to 0.05. In the benchmark case, we set male desire for sex σ^M to 1 and σ^F to 1/2. We set $\delta = 0.45$ and $\theta = 0.2$. This implies that female labor supply is about 30 percent of male labor supply, 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 θ and δ 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 the 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 μ. For this purpose, we assume that the traditional method consists of an average of no contraception at all (failure rate 0.85) 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 of rubber condoms (failure rate 0.45) and latex condoms (failure rate 0.175), which became available in the 1920s.[9] 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, that is, 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 shows the implied development. The upper left panel shows the evolution of actual and wanted fertility. Before the onset of contraceptive use, fertility desired by men (dash-dotted line) slightly exceeds actual fertility (solid line) while women's wanted fertility (dashed line) lies markedly below actual fertility. The model predicts a male-female fertility differential of 0.92, a

[9] The failure rate provides the probability to become pregnant when engaged in sex for a year at normal frequency (Greenwood and Guner (2010, p. 905).

Figure 2: Long-Run Adjustment Dynamics: Basic Model



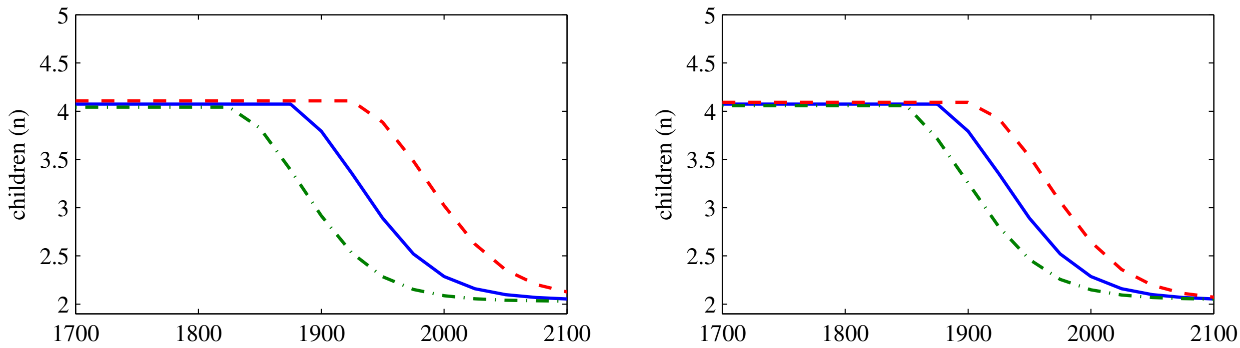
Top left panel: fertility n_t (solid line) and wanted fertility by women (dashed line) and men (dash-dotted line).

figure that coincides roughly with the average fertility differential of 1.0 in the DHS sample of countries from Figure 1. After the onset of contraceptive use in 1900, fertility declines and the wanted fertility of women exceeds that of men and the distance between the wanted fertility 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. Moreover, the increase of contraceptive use is accompanied by an increase in sexual intercourse in marriage. The time that a couple spends on having sex, τs_t, triples with a shift from pre-industrial times to the modern steady state.[10]

The model also provides a strong explanation for the rise of female labor supply. The explanation relies solely on the uptake of contraception and the associated demographic transition. The female/male labor ratio is predicted to be about 0.6 at the end of the 20th century while the actual

[10]For most of human history there exist no quantitative studies on the frequency of sexual intercourse. According to the first reliable study, frequency increased by 25 percent between 1965 and 1975, see Trusell and Westoff (1980) who also documented a positive association of coital frequency with the use of effective contraceptive methods. For the 1990s, Janus and Janus (1993) report that 85 percent of married people in their sample enjoy sexual activity at least weekly. For the time before the mid 20th century we have to rely on historical narratives. Here, scholars agree that the arrival of new methods of birth control led to the demise of the 19th century Victorian prescriptions about continence and self-control (D'Emilio and Freedman, 1988, Ch. 10).

Figure 3: Long-Run Adjustment Dynamics: Sensitivity Analysis



Left: Female Power: basic run, $\theta = 0.2$ (solid line), $\theta = 0.19$ (dashed line) and $\theta = 0.21$ (dash-dotted line). Right: Desire for Sex - Differential: basic run, $(\sigma^M - \sigma^F) = 0.5$ (solid line), $(\sigma^M - \sigma^F) = 0.55$ (dashed line), $(\sigma^M - \sigma^F) = 0.45$ (dash-dotted line).

number was about 0.85 (Goldin, 2014). In Section 5, we consider endogenous bargaining power and a closing gender wage gap in order to explain the remaining 25 percent.

We next look at the quantitative impact of female empowerment and the desire for sex and resolve, for the numerical example, the remaining ambiguities from the theory section. The panel on the left-hand side of Figure 3 shows results for alternative values of θ. Solid lines reiterate the benchmark case from Figure 2. Dashed lines show results for $\theta = 0.21$ and dash-dotted lines show results for $\theta = 0.19$. The figure suggests a strong dynamic effect of female empowerment through education. When θ rises from 0.19 to 0.21, the threshold $\bar{h}$ declines only slightly, by about one percent (which, taken for itself, does not change the onset of the fertility transition). However, the threshold is reached much earlier through the impact of female empowerment on education and growth of human capital. As a consequence, a two percentage point increase in θ motivates about a century earlier occurrence 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 women 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 σ^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 θ and the gender gap δ. A plausible and empirically supported assumption is that female negotiation power in household decision making depends positively on the relative income that the women contributes to household income (Basu, 2006; Rahman and Rao, 2005; Anderson and Eswaran, 2009). A reasonable benchmark is that spousal power equalizes when there are equal contributions to household income. If contemporaneous bargaining power is determined by the contemporaneous income gap, there are potentially multiple coordination equilibria. In order to avoid this additional complication, I assume that contemporaneous bargaining power depends on the last period's income gap, such that θ is a pre-determined dynamic variable, captured by the formula $\theta_{t+1} = 0.5(y_t^F/y_t^M)^\beta$. The parameter β controls how quickly female empowerment adjusts with the 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 that results *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 δ_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

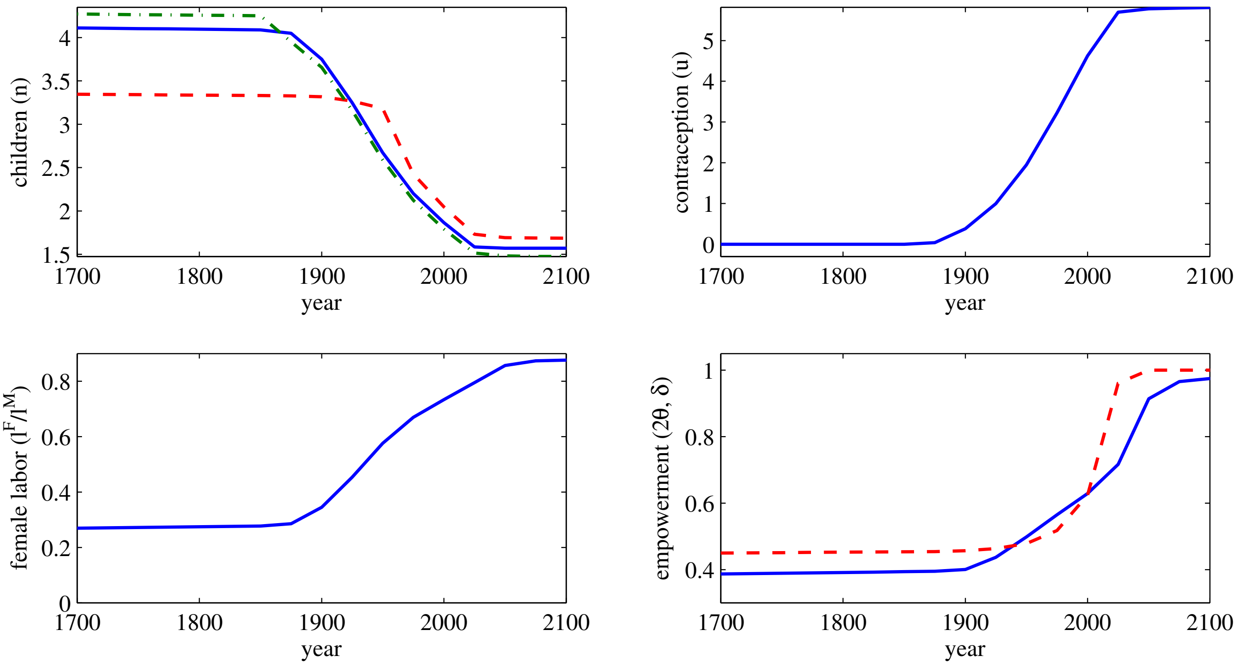
$$\theta_{t+1} = \frac{1}{2}\left(\frac{\delta_t\left[1-\epsilon n_t-(1-\theta_t)\phi n_t\right]}{1-\theta_t\phi n_t}\right)^\beta. \tag{13}$$

Notice that the use of modern contraceptives increases female bargaining power since $\partial\theta_{t+1}/\partial n_t < 0$. This creates an amplifier that speeds up the fertility transition.

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 δ_t is increasing in average human capital, reflecting, for example, the comparative advantage of women in skill-intensive occupations (as in Galor and Weil, 1996) or an impact of education on the appreciation of equality and women's rights. A parsimonious way to implement these ideas is the following formula:

$$\delta_t = \min\left\{1,\ \ \delta_0 + \delta' h_t\right\}, \tag{14}$$

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



Top left panel: fertility n_t (solid line) and wanted fertility by women (dashed line) and men (dash-dotted line). Bottom right panel: empowerment, 2θ (solid line), gender wage gap δ (dashed line).

and $\delta_0, \delta' > 0$. According to (14), the gender wage gap disappears when human capital is sufficiently large. Gender power θ nevertheless remains unequal as long as some female child bearing and rearing tasks are not negotiable (as long ϵ is positive). Setting δ_t to unity in (13) we see that the solution converges to $\theta = 1/2$ for $\epsilon = 0$ and to some smaller value of θ for $\epsilon > 0$.

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

In order to approximate the historical evolution of female labor supply in the U.S. (Goldin, 2014), I set $\delta_0 = 0.42$ and $\delta' = 0.0008$. I set $\beta = 0.5$ in order to obtain a female/male labor force participation of about 25 percent at the dawn of the fertility transition (Goldin, 2014). I keep all parameter values from the benchmark model.

The resulting adjustment dynamics are shown in Figure 4. As in the basic model, the take-off to growth is in sync with the uptake of modern contraceptives and the onset of the fertility transition. In line with the historical evidence, the model predicts that female labor force participation starts to increase already in the early 20th century whereas much of the gender wage gap closes only in the late 20th century (Goldin, 2014). For the year 2000, the model closely predicts the actual U.S. female/male labor participation rate (85 percent) and the actual wage gap (70 percent). Otherwise, the extension preserves the results from the basic model. The main difference from the basic model is that the predicted time of the fertility transition is now much shorter. The transition ends about a century earlier, at the end of the 20th century. Endogenous bargaining power and gender wage gap are amplifying the transition speed.

In contrast to the basic model, fertility is predicted to fall below the replacement level in the late 20th century, as observed for most European countries (UN, 2011) as well as non-Hispanic white U.S. Americans (U.S. National Center for Health Statistics, 2010). The reason is that the uptake of contraceptives and the demographic transition is associated with a closing gender wage gap δ. The closing wage gap leads to higher opportunity costs of children, and thus, to lower fertility and more education.[11] Having more education amplifies income growth and leads to a further decline of the gender gap for the next generation. It is thus through the uptake of modern contraceptives and the child-quality quantity trade-off that female empowerment becomes an essential driver of sustainable development.

5.2. **Gender-biased Education.** In the West, for most of the time during the historical fertility transition, girls received on average less education than boys (Goldin, 2014). Although much progress has been made since, female higher education still lags behind male education 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 not only interested in the human capital of their children but also in the human capital (i.e. potential income) of their children's future family in adulthood. The fact that parents cannot control the human capital of their offspring's future spouses creates an externality and confounds the optimal solution for the division of schooling expenses among sons and daughters. 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.

[11]To see the impact of the gender gap on fertility, take the derivative of (5b) with respect to δ:

$$\frac{\partial n_t}{\partial \delta} = -\frac{(\alpha-\gamma)\mu h\left[p+\mu h(\epsilon+\phi-2\phi\theta)\right]}{\left[1+\alpha+\theta\sigma^F+(1-\theta)\sigma^M\right]\left\{\mu\epsilon\delta h_t+\mu\phi h_t\left[\theta+(1-\theta)\delta\right]-p\right\}^2} < 0$$

since $\theta \leq 1/2$.

Consider a family in which there is in equal number of girl and boy offspring and assume that the spouses do not discriminate based on gender. Specifically, let the former utility weight of human capital per child (γ) be equally divided in human capital in the future households of both sons and daughters. This means that utility function (1) is replaced by

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

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) is now

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

As before, human capital is produced linearly from education expenditure

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

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

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

in which $\bar{e}_t^j$, $j = M, F$, is the expected education of their children's future spouses and λ 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. 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:

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

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

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

For $h_t^M = h_t^F$ the solution (22) 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 modern contraceptives is obtained as

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

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

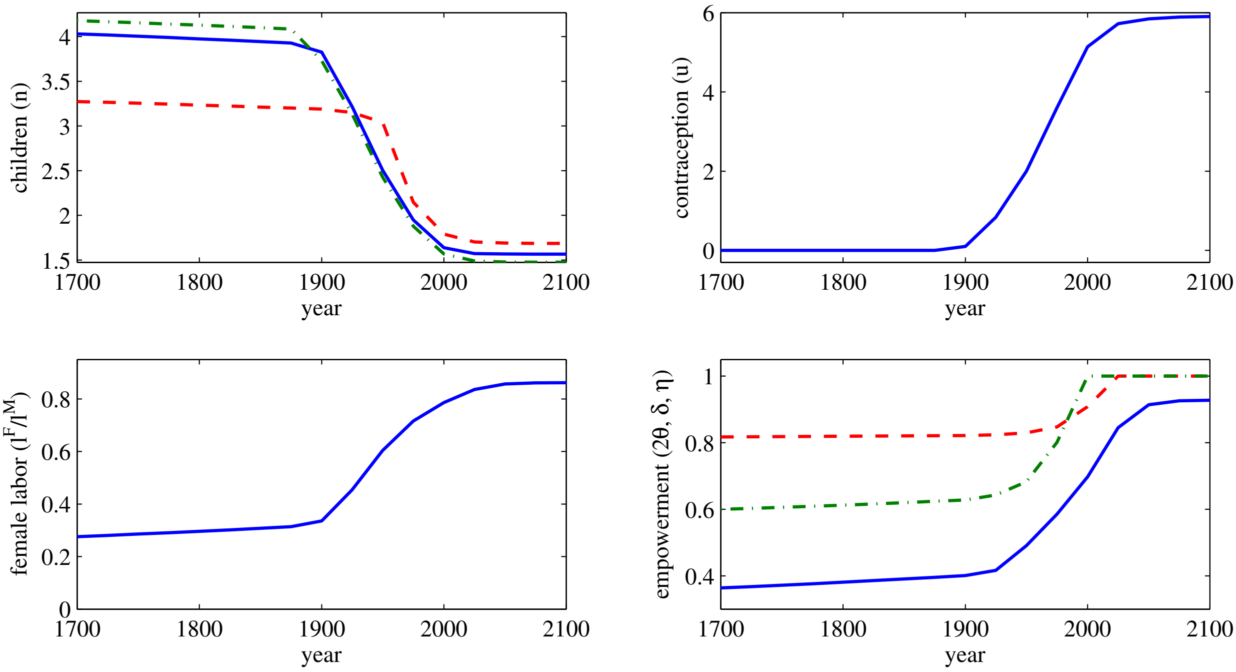
Proposition 9. *At the modern equilibrium as well as at the traditional equilibrium, better education of fathers and mothers increases total education expenditure of the family. Better education of mothers always reduces fertility. Better education of fathers increases fertility at the traditional equilibrium. It increases fertility at the modern equilibrium only if*

$$1 - \frac{\theta\phi\mu(\delta h_t^F + h_t^M)}{\mu\epsilon\delta h_t^F + \mu\phi\left[(1-\theta)\delta h_t^F + \theta h_t^M\right] - p} > 0. \tag{21}$$

For the proof, we inspect the derivatives of e_t in (19b) and (20b) with respect to h_t^M and h_t^F and observe that they are unambiguously positive. We then inspect the derivatives of n_t in (20a) and observe that the sign is determined by the sign of $\epsilon + \phi(1-2\theta)$, which is always positive since $\theta \leq 1/2$. Finally, we inspect the derivative of n_t in (19a) with respect to h_t^M and obtain condition (21). The first term on the left-hand side of (21) is the positive (pure) income effect of male income on fertility. The second term is the indirect negative effect through male participation in child rearing. It vanishes for declining female negotiation power (for $\theta \to 0$). Condition (21) can be further simplified to $p/\mu < \delta h_t^F\left[\epsilon + \phi(1-2\theta)\right]$. Only if contraceptives are relatively expensive and inefficient (but nevertheless used) and female income is low, condition (21) does not hold and better educated men prefer less children. In this case, their (potentially small) contribution through child rearing dominates the pure income effect.

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, that is by attitudes and beliefs on the desirability of female education. Strulik (2013) provides a micro-founded model of the evolution of norms with respect to child labor and education. Here, for

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



Top left panel: fertility n_t (solid line) and wanted fertility by women (dashed line) and men (dash-dotted line). Bottom right panel: empowerment, 2θ (solid line), gender wage gap δ (dashed line), female-male education ration (dash-dotted line).

simplicity, I implement a "reduced-form" model, based on the idea that the level of male education affects a family's attitudes towards gender-specific education. The reduced form could capture the notion that increasing knowledge reduces traditional beliefs 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 higher interest in the wellbeing of their daughters (Doepke and Tertilt, 2009).[12] A parsimonious formulation for the evolution of $e_t^F/e_t^M \equiv \eta_t$ is

$$\eta_t = \min\left\{1,\ \ \eta_0 + \eta' h_t^M\right\}, \tag{22}$$

implying $h_t^F = \eta h_t^M$ and a gender wage gap of $\delta\eta$.

The introduction of an education bias allows us to disentangle the effects of education and wage-discrimination on the gender bias in earnings. To show this with a numerical experiment, I keep the model parameter values as specified for the basic model and set $\eta_0 = 0.55$, $\eta' = 0.002$, $\delta = 0.81$, and $\delta' = 0.00003$, in order to approximate the historical evolution of gender gaps in education and in labor income in the U.S.

[12]In Lagerloef's (2003) original contribution, the education gap is assumed to be a function of calender time. This approach is less suitable here since it prevents the discussion of cross-country differences in attitudes towards female education.

Results for the long-run evolution of the economy are 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). 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 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, 2014), a gender gap in earnings per time unit 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 also allows for a different mechanism determining female power in the household. It has been argued (Pollak, 2005) that female education is a better proxi for power in the household because it better captures the wife's outside option (threat point). I thus, as a numerical experiment, 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.

6. Conclusion

The here proposed theory of sexual desire, female empowerment, and long-run development focusses on sex in marriage (or long-run relationship) and ignores casual sex. Without further assumptions, however, we could expect results to be robust against the introduction of casual sex – as long as it remains true that men prefer more sex in marriage than women. Casual sex, however, provides an alternative motivation to use modern contraceptives (i.e. condoms). An extension of the model could investigate the role of casual sex and health concerns. The fear of sexually transmitted diseases would exert a positive external effect on the fertility transition with a potential feedback on female empowerment. Another interesting extension could look into gender-specific control of contraceptives and non-cooperative bargaining. In such a setting, modern contraceptives would assign more bargaining power to women who, at the extreme, could be Stackelberg leaders in a non-cooperative game.

While these extensions are interesting, they would most likely not change the general message conveyed by the basic model, namely that the gender-specific desire for sex is one channel through which small changes in female empowerment at the micro level can have large macroeconomic consequences. The mechanism proposed in this paper operates through the differentiated onset of the fertility transition. Accounting for a gender-specific desire for sex, small differences in female empowerment can explain large differences in the timing of the take up of modern contraceptives, the onset of the demographic transition, and the take-off to modern growth. The different timing of the take-off then motivates the observed variance in the level and speed of economic development across countries (Galor, 2005, 2011). The theory is thus helpful in explaining the strong, positive association between female empowerment and economic development (Doepke et al., 2012) and supports the United Nations' (1995, 2013) view of a causal impact of female empowerment on macroeconomic performance.

Earlier related studies on the impact of female empowerment on long-run growth were based on the assumption of gender differences in the preference for fertility or child education. Here, in contrast, we considered a gender-specific desire for sex and gender differences in wanted fertility and education that were derived and not imposed. The model explains why, at low levels of development, men want more children than women while it is the other way round at high levels of development. The "Wanted Fertility Reversal" emerges endogenously with the use of modern contraception. Female empowerment at low stages of development reduces fertility and increases education. Thus it leads to an earlier use of modern contraceptives, an earlier and faster fertility transition, and a quicker take-off to modern growth.

Appendix A: Proof of Proposition 4

From Proposition 2 we have that fertility at the modern equilibrium fulfills

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

that is

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

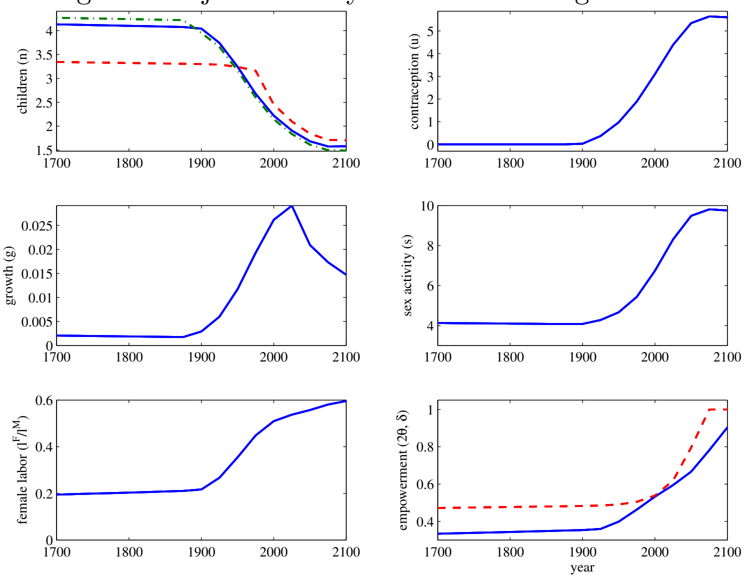
that is

$$LHS < RHS, \qquad LHS \equiv \frac{(\alpha-\gamma)(1+\delta)\mu h_t}{\left[1+\alpha+\theta\sigma^F+(1-\theta)\sigma^M\right]\left\{\mu\epsilon\delta+\mu\phi\left[\theta\sigma^F+(1-\theta)\sigma^M\right]-p\right\}}$$

$$RHS \equiv \frac{\left[\alpha-\gamma+\theta\sigma^F+(1-\theta)\sigma^M\right](1+\delta)}{\left[1+\alpha+\theta\sigma^F+(1-\theta)\sigma^M\right]\left[\phi\theta+\phi(1-\theta)\delta+\epsilon\delta+\tau(1+\delta)\right]}.$$

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).

Figure A.1: Long-Run Adjustment Dynamics: Declining Returns in Education



Appendix B: Declining Returns in Education

In order to discuss declining returns in education, we reformulate the equation of motion for human capital as $h_{t+1} = A[(1-\lambda)e_t + \lambda e_t^{\psi}]$ and $\lambda = \min\{1, \omega h_t\}$. This means that returns are linear when human capital is very low and are then declining towards zero. We set $\omega = 0.002$, $\psi = 0.85$ and keep all parameter values from the model variant of Section 5.1 in the main text. Figure A.1 shows that adjustment dynamics leading up to the 21st century look very similar to those predicted for the linear model. However, due to decreasing returns, there is no long-run growth. Growth reaches a peak in the early 21st century and then starts declining. At this time, however, all other model variables have almost reached their steady state levels, which is the reason why the transition phases look so similar for both scenarios.

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