Beauty, Polygyny, and Fertility: Theory and Evidence

Cahu, Paul and Fall, Falilou and Pongou, Roland

European Investment Bank, Université de Paris 1, Sorbonne, University of Ottawa

1 September 2014

Beauty, Polygyny, and Fertility: Theory and Evidence

Paul Cahu, Falilou Fall, and Roland Pongou[1]

This Version: September 2014

Abstract: We propose a simple model of a mating economy in both monogamous and polygynous cultures, and derive implications for how polygyny affects individual and aggregate fertility. We find that an attractive woman is more likely to find a high-status husband. However, when polygyny is allowed, high-status husbands naturally attract other women; this implies that female beauty increases the likelihood of entering into a polygynous relationship. A woman in a polygynous relationship produces fewer children than a woman in a monogamous relationship as long as the preference for reproduction relative to consumption is not too strong. However, the societal practice of polygyny increases aggregate fertility through two distinct channels: (1) by increasing the number of marriages; and (2) by triggering *fertility contagion*: a woman, whether involved in a monogamous or polygynous relationship, produces more children as polygyny becomes more prevalent in her neighborhood. We empirically validate each of the model's key predictions.

Keywords: Mating Economy, Monogamy, Polygyny, Beauty, Status, Fertility, Contagion, Networks

JEL Classification: A13, C78, J12, J13, Z10

---

[1]Paul Cahu (p.cahu@eib.org) is at the European Investment Bank; Falilou Fall (falilou.fall@univ-paris1.fr) is at Centre d'Economie de la Sorbonne, Université Paris 1; and Roland Pongou (roland.pongou@uottawa.ca) is at the Department of Economics of the University of Ottawa. Fairooz Reaz provided excellent research assistance. We thank Ingela Alger, Jakina Debnam, Marcel Fafchamps, James Fenske, Andrew Foster, Isaac Mbiti, Pierre Evariste Nguimkeu, Pauline Rossi, Paul Schultz, Michel Tenikue, Leonard Wantchekon, Joshua Wilde, and several participants at the Conference on the Economics of the Family in Paris and the CSAE conference at the University of Oxford for useful comments and suggestions. Roland Pongou acknowledges research grant from the Social Sciences and Humanities Research Council of Canada.

1 Introduction

> The maternal instinct leads a woman to prefer a tenth share in a first rate man to the exclusive possession of a third rate – *George Bernard Shaw In Maxims for Revolutionists (1903)*

The last five decades have witnessed an important growth of the literature on two-sided matching and its applications to the marriage market. Most studies, however, have focused on the formation of relationships in monogamous societies, with little attention paid to polygyny, a form of plural marriage involving one man and more than one woman, which has existed for millennia and continues to exist in many contemporary societies. Therefore, differences in marriage patterns and outcomes across societies with different matrimonial cultures have not been sufficiently studied. In this paper, we propose a simple model of a mating economy to analyze and compare marriage in monogamous and polygynous societies. We subsequently derive implications for how polygyny affects male and female fertility at both the individual and aggregate levels.

The focus on fertility as an outcome naturally comes from the fact that the desire for progeny is generally regarded as one of the strongest appeals of polygyny: a large number of children in a household constitutes an important workforce, ensures family continuity through reproduction, and brings prestige to parents. However, the question of how polygyny affects fertility has not been resolved in the literature. Tertilt (2005) finds that women living in polygynous countries have 2.2 more children than those in monogamous countries. In an earlier work, however, Muhsam (1956) found that the number of children was 32 percent lower for women married to polygynous men than for their counterparts married to monogamous men. Busia (1954), on the other hand, found no significant difference in the fertility of women in monogamous relationships and those married to polygynists.

These previous studies clearly show that the effect of polygyny on fertility varies significantly, and may also depend on whether it is assessed at the individual level or at the aggregate level. There is therefore a need to understand the mechanism through which polygyny affects fertility. Ideally, such a mechanism should also shed light on the characteristics of individuals who choose to be involved in a polygynous marriage, and elucidate the role that these individual characteristics play in the relationship between polygyny and fertility.

1.1 An overview of the model

The model proposed in this paper assumes a world in which agents marry in the first period and produce children in the second. First, we consider a *two-sided mating economy* involving men and women. These men and women are ranked according to objective criteria. Each individual derives utility from having a marital relationship with an individual of the opposite sex, and a higher-ranked individual is more desired as a partner. We study the equilibrium matching of this economy in both the monogamous and the polygynous cultures, and derive implications for how polygyny affects the marriage rate, and how individual characteristics determine the likelihood of entering a polygynous marriage. Building on this, the second component of the model analyses the relationship between polygyny and fertility.

In our two-sided mating economy model, the assumption that the social rank of an individual determines his/her desirability as a partner is consistent with experimental studies that have found that women look for *status* and *wealth* in men, whereas men look for *beauty* in women (Todd et al. 2007). Similarly, Becker (1974) assumes an objective ranking of men and provides an argument for why a woman would want to marry a high-status man who might attract other wives in a culture of polygyny.[2] Following Becker's work, many studies assume partner selection to be based on one characteristic (e.g., wages, income, education, height, weight, body mass index) or a set of characteristics combined into a single objective variable (e.g., Becker 1981; Pencavel 1998; Choo and Siow 2006; Chiappori, Oreffice, and Quintana-Domeque 2012). However, as we explain later, our models differ significantly.

We show that there exists a unique equilibrium matching under each of the two matrimonial cultures considered in the analysis. For each of these cultures, we describe this equilibrium in terms of the number and quality of partners that each individual obtains. In a monogamous culture, men match with women of comparable rank, meaning that high-status men match with attractive women, whereas low-status men match with unattractive women. In a polygynous culture, women match with men whose status is comparatively higher than their beauty rank. Moreover, beautiful women are more likely to enter a polygynous relationship, with the number of co-wives increasing with the social status of their husband. Intuitively, this is driven by the fact that higher-ranked individuals are more desirable as partners, therefore a beautiful woman is more likely to marry a high status man, who also attracts other women.

Departing from the traditional literature on marriage, we further extend our mating economy model to allow for the possibility of beauty being judged subjectively by men, that is, each man is allowed to have a different ranking of women. Remarkably, this extension preserves the existence and uniqueness of the equilibrium matching in each matrimonial culture.

Analyzing the implications of these results for marriage rate, we find that allowing polygyny increases all women's chances of getting married. This implies that the aggregate number of marriages is higher in a polygynous culture than in a monogamous culture.

In the second component of the theory, we study the effect of polygyny and polygyny prevalence on fertility at both the individual and aggregate levels. In the model, each individ-

[2] Becker (1974) supports the view expressed in our introductory quote, and argues that prohibiting polygyny may be seen as an example of "discrimination" against women. Indeed, he writes that an "alternative interpretation of the religious and legislative strictures against polygyny is that they are an early and major example of discrimination against women, of a similar mold to the restrictions on their employment in certain occupations, such as the priesthood, or on their ownership of property."

ual derives utility from the number of children and from other consumption goods. It is also assumed that the number of children increases the prestige rank of their parents. We derive the following predictions.

First, a woman in a monogamous relationship has more children than a woman in a polygynous relationship, unless the preference for children relative to other consumption goods is too strong, in which case, the opposite might hold. Indeed, a woman involved in a polygynous relationship competes with her co-wives for the man's attention and resources, which, under certain natural assumptions, leads to a smaller number of children than she would have if she were the only wife. This negative effect of polygyny on female fertility at the individual level holds as long as resources are allocated in fixed proportions between children and other goods, or if the marginal value of children is not too high. When the preference for children is sufficiently strong, polygyny positively affects female fertility. These findings imply that the effect of polygyny on fertility at the individual level might vary across cultures, following variation in the value attached to children. In contrast, polygyny unambiguously positively affects male fertility, since the number of children that a man produces is the sum of children born to his wives.

Second, although the effect of being involved in a polygynous relationship on female fertility is ambiguous, polygyny prevalence under natural assumptions increases aggregate fertility through two distinct channels: (1) by increasing the number of marriages as argued earlier; and (2) by triggering *fertility contagion*: any individual, whether involved in a monogamous or polygynous relationship, tends to produce more children as polygyny becomes more prevalent in his/her neighborhood.

To the best of our knowledge, this study is the first to document the *contagious effect* of polygyny on fertility, even among monogamous women. We show that the contagious effect of polygyny on individual fertility proceeds from fertility itself being *contagious* in the sense that the number of children that an individual produces is positively affected by the number of children produced by other individuals in his/her neighborhood. This is because the number of children determines the "prestige rank" of parents. Therefore, as an individual's neighbors produce more children, the rank of that individual decreases, inciting him/her to produce more children in order to maintain his/her social rank. This contagious effect of fertility implies that in polygynous societies, exposure to polygynous men and their large number of children incites individuals to produce more children than they otherwise would if they had only monogamous neighbors.

By showing how polygyny might affect individual and aggregate fertility differently, our analysis offers a simple framework that unifies the mixed empirical findings on this topic. We also test our model empirically, mainly focusing on its most important and novel predictions.

1.2 An overview of the empirics

We test the empirical predictions of the model using nationally and sub-nationally representative household data from Demographic and Health Surveys from 32 sub-Saharan African countries. These surveys contain information on a wide range of topics including health, fertility, and the socioeconomic and demographic characteristics of individuals, households and neighborhoods.

We first test the prediction that beautiful women are more likely to enter a polygynous relationship. The main challenge associated with this test stems from the fact that beauty is hard to measure, and in fact, several measures of physical attractiveness have been used in the literature. In general, the appreciation of female attractiveness varies across the world. Some components of external beauty such as low waist-to-hip ratio (Singh 1995) and clear complexion (Symons 1979) are agreed upon across most cultures. However, other attributes such as weight and skin tone vary across cultures and time. In renaissance art, most women depicted are large with pale skin. Both of those features were contemporary indicators of wealth and good health. In contrast, most of the women displayed in media as symbols of beauty today are thin and tall, with tanned skin. Models across the world are much taller than average and beauty pageants are dominated by tall, thin women. Consistent with these facts, we find that the average height of the winners of Miss Universe from 1980-2011 is 1.75 m, and that all the winners are taller than the average woman of their nationality.

It follows that several measures of beauty, including waist-to-hip ratio, skin complexion, weight, height[3], and body mass index (weight in kilograms divided by the square of height in meters), have been used in the literature. Of these measures, weight, height, and the BMI are the most popular, perhaps because of their availability in most datasets (e.g., Nettle 2002; Smits 2012; Chiappori, Oreffice, and Quintana-Domeque 2012). The DHS data have information on these anthropometric indicators. Therefore, we use all the three indicators to proxy beauty. However, only height appears to produce results that are consistent with the predictions of our model. The reason seems simple in our context. Owing to the cross-sectional nature of the DHS, height is more useful than weight and BMI as a predictor of a possibly past outcome such as marriage, because height is more stable over time after a certain age than the other measures. Indeed, "current" weight and BMI are not appropriate measures of "past" beauty because the weight and BMI of a married woman measured at the survey may be very different than when she got married, and will therefore fail to explain her "past" marriage outcome. But such a woman most likely has the same height as when she got married, and so, "current height" as a measure of beauty can explain her "past" marital success.

[3]Height has also been shown to predict social and economic attractiveness, as taller individuals select into higher-status occupations and earn more than other workers (Case and Paxson 2008; Schultz 2002; Persico, Postlewaite and Silverman 2004).

We find that taller women are more likely to find a marital partner. They more often marry polygynous men than monogamous men. These results may have two apparently contradictory implications for how height affects fertility. The fact that height increases the prospect of marriage implies that taller women are more likely to have "at least" one child, since marriage increases the probability of childbearing. However, the fact that taller women are more likely to enter a polygynous relationship than shorter women does not have a clear theoretical implication for how beauty affects the number of children. We indeed find that taller women are more likely to have a child, but condional on being fecund and on marital status, height does not affect the number of children. Consistent with theory, height therefore affects female fertility at the extensive margin, but not at the intensive margin.

We also test the micro-level mechanism through which societal polygyny affects aggregate fertility. As noted earlier, according to the theory, polygyny prevalence increases aggregate fertility: (1) by increasing the number of marriages; and (2) by triggering fertility contagion. We indeed find that a woman is more likely to get married when polygyny is more prevalent in her region of residence, validating the first channel. This finding is robust to alternative measures of marital success. For instance, societal polygyny reduces the likelihood of divorce and increases the likelihood of remarriage.

We also validate the second channel, showing that a woman, whether involved in a monogamous or a polygynous relationship, has more children as the prevalence of polygyny in her region of residence increases. Using average height as an instrument for polygyny prevalence, we find that a change from a regime of complete monogamy to a regime of complete polygyny increases the number of children produced by an average woman by about 3.6. Remarkably, we find the same estimate when testing the contagious effect of polygyny prevalence over the sample of only *monogamous women*.

Our test of the contagious effect of polygyny on individual fertility using the full sample of women controls for whether a woman is married to a polygynist or not, which allows us to test the prediction of the model regarding the effect of polygyny on female fertility at the individual level as well. We find that a woman involved in a polygynous relationship has fewer children than a woman involved in a monogamous relationship. This effect is robust to the inclusion of a range of controls.

It clearly follows from these analyses that, while polygyny prevalence positively affects individual fertility (regardless of whether a woman is involved in a monogamous or polygynous relationship), being married to a polygynist negatively affects fertility. However, in absolute value, the former effect strongly dominates the latter effect, so that the societal practice of polygyny positively affects individual and aggregate fertility as predicted by the theory.

The paper is organized as follows. Section 2 highlights the contributions of our study to the closely related literature. Section 3 presents the theoretical model, and Section 4 presents its testable implications. The model is tested in Section 5. Section 6 concludes.

2 Closely related literature

Our paper is related to the theoretical and empirical literature on sexual matching and the formation of marital relationships. Like our study, most of work in this area assumes that the matching process is based on one characteristic of socioeconomic or physical attractiveness (e.g., wages, income, education, height, weight, body mass index) or a set of characteristics combined into a single objective variable, and so assumes individuals have identical preferences over the opposite sex (e.g., Becker 1981; Pencavel 1998; Choo and Siow 2006; Chiappori, Oreffice, and Quintana-Domeque 2012). Our analyses however have significant differences. We assume a discrete framework and ordinal preferences such as in Gale and Shapley (1962), whereas most studies assume matching based on continuous characteristics. We therefore use different mathematical tools to identify equilibrium matchings. Also, whereas existing studies mainly analyze the monogamous marriage market, we also study marriage in a polygynous culture, uncovering new theoretical results. Moreover, we relax the assumption of homogeneity in male preferences, allowing female beauty to be judged subjectively by men. Remarkably, this more general model preserves the uniqueness of the equilibrium matching found in the more restrictive framework where preferences are defined objectively for both men and women.

Our analysis of matching in a polygynous culture also relates to pioneering works by Becker (1974, 1981) and Grossbard (1978). These studies analyze the causes of polygyny and its consequences on economic productivity, household resource allocation, and welfare (see also Jacoby (1995) and Fenske (2013)). Bergstrom (1994) extends these earlier analyses by incorporating the desire of individuals to maximize the number of their children and descendants when resources are limited.

Our theoretical framework also complements and reconciles apparently mixed empirical findings on the relationship between polygyny and fertility. Tertilt (2005) shows that polygyny affects aggregate fertility by increasing bride price. She argues that competition for wives in a polygynous society raises bride price; parents therefore have a greater incentive to produce more children as they receive bride price on behalf of their daughters. At the individual level, other studies have found a negative relationship between polygyny and female fertility (e.g., Pebley and Mbugua 1989; Garenne and van de Walle 1989; Timaeus and Reynar 1998; Muhsam 1956), whereas others have found no relationship (e.g., Busia 1954). Our work reconciles these earlier studies by providing a unified framework which allows us to analyze the effect of polygyny and polygyny prevalence on individual and aggregate fertility. We find that although polygyny prevalence increases individual and aggregate fertility, being married to a polygynous man negatively affects individual fertility as long as the preference for reproduction relative to consumption is not too strong. Further incorporating envy into our model shows that the societal practice of polygyny triggers fertility contagion, which positively affects the fertility of even monogamous couples.

We also test the key predictions of our model, therefore contributing to the empirical literature on the determinants of fertility. Fertility has been related to mortality (see, e.g., Nerlove 1974; Dyson 2010; Kalemli-Ozcan 2002; Doepke 2005; Fernández-Villaverde 2001), income (Becker 1960; Jones and Tertilt 2006), human capital, and female labor participation (e.g., Galor and Weil 1996 1999, 2000; Galor and Moav 2002; Murphy 2009; Becker, Murphy and Tamura 1990; Tamura 1996; De La Croix and Doepke 2003; Doepke 2004). Our estimated effects of polygyny on fertility are robust to the inclusion of these other determinants of fertility.

We also view our study as contributing to the theory of endogenous network formation. The analysis shows an instance in which culture and institution shape the configuration of networks. In this respect, the findings complement the study of (in)fidelity networks (Pongou 2009a; Pongou and Serrano 2009, 2013), and highlight differences in partner sorting across monogamous and polygynous cultures.

Several studies have examined the characteristics of polygynous men, showing, for instance, that these men are wealthier or have a higher social status than monogamous men (e.g., Becker 1974). The characteristics of women who enter a polygynous union, however, have not been widely studied. Our model predicts that more attractive women are more likely to be married to polygynous men. This mating pattern has implications for how beauty affects fertility at both the extensive and intensive margins. In particular, the model implies that more beautiful women are more likely to have at least one child. However, it does not yield an unambiguous prediction on the relationship between beauty and number of children. We do not know of any theory with similar predictions. We validate these predictions empirically.

3 A model of polygyny and fertility

Our model assumes that people marry in the first period and produce children in the second period. Following this rationale, we develop our theory in two parts. The first part studies marriage outcomes in monogamous and polygynous cultures, and the second part studies the effect of polygyny on individual and aggregate fertility.

3.1 A hierarchical mating economy

Our setting consists of a non-empty finite set of individuals $N = \{i_1, \dots, i_n\}$ divided into a set of men $M = \{m_1, \dots, m_k\}$ and a set of women $W = \{w_1, \dots, w_k\}$, each of equal size. Men and women are ranked according to an objective criterion (the ranking criterion may be wealth for men and education or beauty for women).[4] Without loss of generality, we assume the rank of m_i to be higher than that of m_{i+1} and the rank of w_i to be higher than that of w_{i+1}, $i = 1, ..., k-1$. Each individual derives utility from having marital relationships with

[4] The ranking criterion for each side of the economy may also be an objective variable that combines a set of ordinal or cardinal characteristics.

the opposite sex, and higher-ranked individuals are more desired as partners. A woman can have at most one partner, whereas a man can have multiple partners depending on whether polygyny is allowed or not. Each man desires to match with a finite number of partners. We further assume that there is a social rank threshold below which a man cannot get married (in other words, men falling below this threshold are unacceptable as partners, although they desire to have sex).[5] Let M_1 represent the set of men who are above this threshold and M_2 the set of men below the threshold (M_2 may be empty).[6] This setting defines what we call a hierarchical mating economy. This definition is more formally summarized below:

Definition 1 *A hierarchical mating economy is a list* $\mathcal{E}^{\succ} = (N = M_1 \cup M_2 \cup W, (s_j^*)_{1 \leq j \leq n}, \succ_m, \succ_w)$ *where:*

- s_j^* *represents the capacity (or number of partners that cannot be exceeded) of individual* i_j*;*
- $\succ_m$ *and* $\succ_w$ *are linear orderings on* M *and* W *representing the rankings of men and women, respectively.* $\succ_m$ *also represents women's preferences over men's ranks and* $\succ_w$ *represents men's preferences over women's ranks.*

As we mentioned previously, we shall assume that $s_j^* = 1$ if $i_j \in W$. Also, on the second interpretation of $\succ_m$and $\succ_w$, we remark that $\succ_m$ is not a ranking of the subsets of the set of men by women as it is often the case in traditional matching problems; $\succ_m$ is a ranking of individual (or singleton) men by women; similarly, $\succ_w$ is a ranking of individual women by men. For our purpose, we do not need a ranking of the subsets of the set of agents on each side of the market.

Our goal is to study the equilibrium matching of this economy under two alternative cultures or institutions, namely a monogamous culture where a man can have at most one partner, and a polygynous culture where a man may have multiple partners. Equilibrium is captured by the notion of *pairwise stability*. According to this notion, a marriage network or matching g, understood as a collection of links between men and women, is pairwise stable if: "(i) no individual has an incentive to sever an existing link in which he/she is involved; and (ii) no male-female pair has an incentive to form a new link while at the same time possibly severing some of the existing links in which they are involved." We provide a more formal definition of pairwise stability below.

[5] This assumption implies that there are more women than men on the marriage market, which has been oberved in most societies. In certain traditional societies, it is common for 18 year old girls to get married, whereas men of the same age may not (UNICEF 2005).

[6] If the set M_2 is empty, it means that there are as many men as women on the marriage market. But as argued above, there are generally more women than men on the marriage market, meaning that M_2 is not empty in general.

Definition 2 *Let* $(\succeq_i)_{i\in N}$ *be a profile of preferences on the set of all possible matchings, and* g *a matching. We say that* g *is pairwise stable with respect to* $(\succeq_i)_{i\in N}$ *if:*

(i) $\forall i \in N$, $\forall (i,j) \in g$, $g \succ_i g \setminus \{(i,j)\}$.

(ii) $\forall (i,j) \in (M \times W) \setminus g$, *if network* g' *is obtained from* g *by adding the link* (i,j) *and perhaps severing other links involving* i *or* j, $g' \succ_i g \Longrightarrow g \succeq_j g'$ *and* $g' \succ_j g \Longrightarrow g \succeq_i g'$.

The following result says that there is a unique pairwise stable matching in this economy. It also provides a characterization of this matching in terms of the number of partners that each individual obtains.

Theorem 1 *There exists a unique pairwise stable matching in this economy. More precisely:*

- *Under a monogamous culture, each man* m_i *is matched with woman* w_i *if* $i \leq k - |M_2|$, *and all men* m_i *and women* w_i *such that* $i > k - |M_2|$ *are unmatched.*
- *Under a polygynous culture,* m_1 *is matched with the first* $s_1 = \min(s_1^*, |W|)$ *highest ranked women,* m_2 *is matched with the next* $s_2 = \min(s_2^*, |W| - s_1)$ *highest ranked women, and so on. Iterating,* m_i *is matched with the next* $s_i = \min(s_i^*, |W| - \sum_{j=1}^{i-1} s_j)$ *highest ranked women,* $i = 2, ..., k - |M_2|$. *And all men* m_i *such that* $i > k - |M_2|$ *and the remaining women are unmatched.*

Proof. The proof is constructive and follows the steps in Pongou (2009a). The unique pairwise stable matching is constructed as follows. Suppose that men and women are lined up according to their social rank. Under monogamy, the highest ranked man m_1 first proposes the highest ranked of his s_1^* most preferred women, who is w_1. The latter accepts since m_1 is her most preferred man. Afterwards, both leave the market. Now comes m_2's turn, who proposes to the highest ranked of his s_2^* most preferred women remaining in the market, who is w_2; the latter accepts, given that m_2 is her most preferred man remaining in the market, both leaving the market afterwards; and so on, until $m_{k-|M_2|}$ last matches with $w_{k-|M_2|}$ and leaves the market. By definition, all men m_i such that $i > k - |M_2|$ will not match, which automatically implies that all women w_i such that $i > k - |M_2|$ will not match either. One can easily prove that the described matching is the unique pairwise stable matching.

Under polygyny, m_1 first proposes each of his $s_1 = \min(s_1^*, |W|)$ most preferred women. The latter accept his proposal given that m_1 is their most preferred man. These newly matched individuals then leave the market. Afterwards, m_2 proposes each of his $s_2 = \min(s_2^*, |W| - s_1)$ most preferred women remaining in the market. The latter accept his proposal given that m_2 is their most preferred man remaining in the market, and these newly matched individuals leave the market afterwards. It follows by induction that man m_i ($i = 2, ..., k - |M_2|$) matches with the next $s_i = \min(s_i^*, |W| - \sum_{j=1}^{i-1} s_j)$ highest ranked women remaining in the market. As under monogamy, it is easy to prove that the resulting matching is the unique pairwise stable matching. ■

We provide below an illustration of this result.

Example 1 *Consider the following hierarchical mating economy with 5 men,* m_1*,* m_2*,* m_3*,* m_4 *and* m_5*, and 5 women,* w_1*,* w_2*,* w_3*,* w_4 *and* w_5*, where the demand for wives by men is* $(s_1^*, s_2^*, s_3^*, s_4^*, s_5^*) = (2, 2, 1, 1, 1)$ *and* $M_1 = M$ *(each man may marry). Under monogamy, the unique equilibrium matching, represented by Figure 1, is the one in which each man* m_i *matches with woman* w_i*. Under polygyny, in the unique equilibrium matching, represented by Figure 2,* m_1 *is matched with* w_1 *and* w_2*,* m_2 *is matched with* w_3 *and* w_4*,* m_3 *is matched with* w_5*, and* m_4 *and* m_5 *are unmatched.*

Figure 1: Monogamy equilibrium

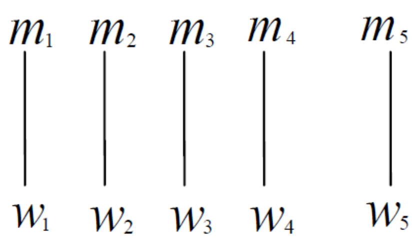
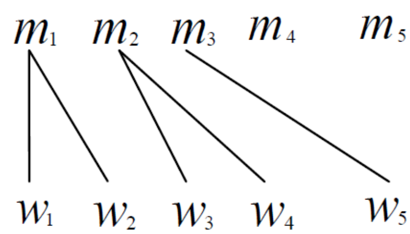
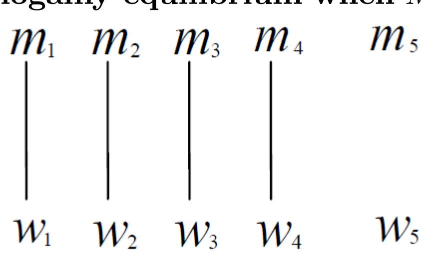


Figure 2: Polygyny equilibrium



Now, suppose that the demand for wives by men is $(s_1^*, s_2^*, s_3^*, s_4^*, s_5^*) = (2, 2, 1, 1, 1)$ *and* $M_1 = \{m_1, m_2, m_3, m_4\}$ *(*m_5 *cannot marry). Under monogamy, each man* m_i *will with woman* w_i *if* $1 \leq i \leq 4$*, and* m_5 *and* w_5 *will be unmatched (Figure 3). Under Polygyny, the unique equilibrium matching will still be the one represented by Figure 2.*

Figure 3: Monogamy equilibrium when M_2 **is nonempty**



We note that while the number of marriages is the same under monogamy and polygyny in the former economy, the situation is quite different in the latter economy, where the number of marriages is greater under polygyny than under monogamy. We shall later generalize this result. We also note that in both economies, the monopolizing power of highest-ranked men deprives their lowest-ranked counterparts of wives.

A testable implication of Theorem 1 stated in Corollary 1 below is that the aggregate number of marriages (or nuptiality rate) is higher under a polygynous culture than under a monogamous culture.

Corollary 1 *1) The aggregate number of marriages is higher under a polygynous culture than under a monogamous culture.*

2) A woman's probability of getting married is greater in a polygynous culture than in a monogamous culture.

Proof. 1) Under a monogamous culture, the aggregate number of marriages equals the number of men who may get married, that is $|M_1|$. Under a polygynous culture, each man $m_i \in M_1$ may have at least one wife. So the aggregate demand for women by men who may get married is at least $|M_1|$. But it follows from the construction of the unique pairwise stable matching that arises in a polygynous culture in the proof of Theorem 1 that at least $|M_1|$ women get married, which implies that the number of marriages under polygyny is weakly greater than under monogamy. The inequality is strict if $s_i^* > 1$ for some man $m_i \in M_1$.

2) The proof follows from the proof of 1). ■

Another testable implication of Theorem 1 is that if the maximum number of partners that a man may have is increasing in his social rank, then higher-ranked women (or more beautiful women) have greater chance to enter a polygynous relationship, with the number of co-wives increasing with social rank. This result is summarized in Corollary 2 below.

Corollary 2 *If $s_i^* \geq s_j^*$ whenever $i < j$, and if w_i and w_j are married, then the number of wives that w_i' s husband has weakly exceeds the number of wives that w_j' s husband has. The last inequality may be strict.*

Proof. The proof immediately follows from the construction of the pairwise stable matching in the proof of Theorem 1. ■

We note that a situation where the number of women that a man may have increases with his social rank is when social rank is measured by wealth and wealth buys women (maybe in the form of bride price). Interestingly, Corollary 2 also implies that more beautiful women are more likely to be cheated upon by their husband. This is because more beautiful women marry wealthier men, who attract other women.

3.2 Beauty is subjective

We consider a variant of a hierarchical mating economy in which men are ranked the same way by the women, but each man has his own ranking of women. The motivation here is that if the desirability of a woman as a partner is based, for instance, on how beautiful she is, each man may have a different definition of beauty. For example, if beauty is determined by height, a man may not want his wife to be much taller than he is. Since men differ in height, they rank women differently. We will call it a hierarchical mating economy when all the members of a group have identical preferences over the members of the opposite group. When differentiated preference structures are allowed for members of one group, we will call it a hierarchical mating economy with one-sided subjective rankings.

Definition 3 *A hierarchical mating economy with one-sided subjective rankings is a list* $\mathcal{E}^{\succ} = (N = M_1 \cup M_2 \cup W, (s_j^*)_{1 \leq j \leq n}, \succ_m, (\succ_w^m)_{m \in M})$ *where:*

- s_j^* *represents the capacity of individual* i_j*;*
- $\succ_m$ *is a linear ordering on* M *representing the ranking of men by all women, and* $\succ_w^m$ *is a linear ordering on* W *representing the ranking of women by man* m*.* $\succ_m$ *also represents women's preferences over men's ranks and* $\succ_w^m$ *represents man* m*'s preferences over women's ranks.*

As for hierarchical mating economies, we find that a hierarchical mating economy with one-sided subjective rankings has a unique pairwise stable matching. We also give a description of this matching in terms of the number of partners that each individual obtains.

Theorem 2 *There exists a unique pairwise stable matching in a hierarchical mating economy with one-sided subjective rankings. More precisely:*

- *Under a monogamous culture,* m_1 *is matched with "his" highest ranked woman, each man* m_i $(i = 2, ..., k - |M_2|)$ *is matched with "his" highest ranked woman (not matched with* m_j*,* $j = 1, ..., i-1$*) if* $i \leq k - |M_2|$*, and all men* m_i *such that* $i > k - |M_2|$ *and the remaining women not matched with any man in* M_1 *are unmatched.*
- *Under a polygynous culture,* m_1 *is matched with "his"* $s_1 = \min(s_1^*, |W|)$ *highest ranked women,* m_2 *is matched with "his"* $s_2 = \min(s_2^*, |W| - s_1)$ *highest ranked women (not matched with* m_1*), and so on. Iterating,* m_i *is matched with "his"* $s_i = \min(s_i^*, |W| - \sum_{j=1}^{i-1} s_j)$ *highest ranked women (not matched with* m_j*,* $j = 1, ..., i-1$*),* $i = 2, ..., k - |M_2|$*. And all men* m_i *such that* $i > k - |M_2|$ *and the remaining women are unmatched.*

Proof. The reasoning is similar to that of Theorem 1 and so, the proof is left to the reader. ■

We illustrate this result in the following example.

Example 2 *Consider the following hierarchical mating economy, analyzed in Example 1, with 5 men,* m_1*,* m_2*,* m_3*,* m_4 *and* m_5*, and 5 women,* w_1*,* w_2*,* w_3*,* w_4 *and* w_5*, where the demand for wives by men is* $(s_1^*, s_2^*, s_3^*, s_4^*, s_5^*) = (2, 2, 1, 1, 1)$ *and* $M_1 = M$ *(each man may marry). The difference is that each man has his own ranking of women. Those rankings are the following:*

$m_1 : w_4 \succ w_1 \succ w_2 \succ w_3 \succ w_5$ *(that is,* m_1 *prefers* w_4 *over* w_1*,* w_1 *over* w_2*,* w_2 *over* w_3*, and* w_3 *over* w_5*)*

$m_2 : w_1 \succ w_3 \succ w_2 \succ w_4 \succ w_5$

$m_3 : w_1 \succ w_4 \succ w_5 \succ w_3 \succ w_2$

$m_4 : w_3 \succ w_2 \succ w_4 \succ w_1 \succ w_5$

$m_5 : w_2 \succ w_1 \succ w_3 \succ w_4 \succ w_5$

Under monogamy, the unique equilibrium matching, represented by Figure 4, is the one in which m_1 *matches with* w_4*,* m_2 *matches with* w_1*,* m_3 *matches with* w_5*,* m_4 *matches with* w_3*, and* m_5 *matches with* w_2*. Under polygyny, the unique equilibrium matching, represented by Figure 5, is the one in which* m_1 *matches with* w_4 *and* w_1*,* m_2 *matches with* w_3 *and* w_2 *(his 2 highest ranked women not matched with* m_1*),* m_3 *matches with* w_5*, and* m_4 *and* m_5 *are unmatched.*

Figure 4: Monogamy equilibrium with one-sided subjective rankings

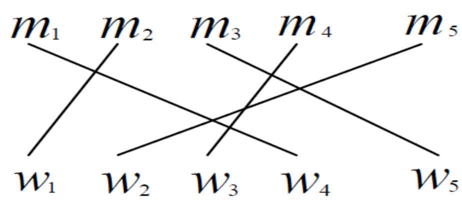
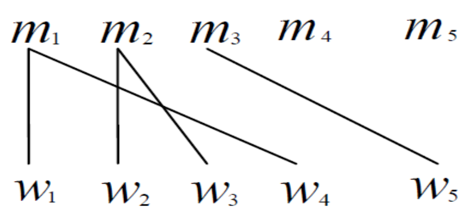


Figure 5: Polygyny equilibrium with one-sided subjective rankings



We remark that the structure of the pairwise stable matching in terms of the distribution of links is the same for the first hierarchical mating economy analyzed in Example 1 and the hierarchical mating economy with one-sided subjective rankings being studied under either monogamy (Figure 1 has the same structure as Figure 4) or polygyny (Figure 2 and Figure 5 have the same structure), but the marriages are different.

As illustrated in Example 2, we note that the unique equilibrium matching which arises in a hierarchical mating economy with one-sided subjective rankings has the same structure as the unique equilibrium matching which arises in the corresponding hierarchical mating economy under either monogamy or polygyny. Both matchings are similar up to permutations of the women, with men having the exact same number of women. This implies that the finding stated in Corollary 1, according to which the number of marriages is greater under a polygynous culture than under a monogamous culture, holds for hierarchical mating economies with one-sided subjective rankings as well.

3.3 The effect of polygyny on individual-level fertility

In this section, we study the effect of polygyny on fertility at the individual level. We conduct this analysis under two alternative preference structures. First, we assume that children are the only consumption good in the household.[7] Under the second structure, parents derive utility not only from the number of children they have, but from other goods too. Another salient feature of the second model is that parents have "others' regarding preferences", owing to the fact that the number of children determines the "prestige rank" of parents, so that having more children than other parents generate greater utility.

3.3.1 Children as the only good

Assume that a man m has l wives $w_1, ..., w_l$. Each individual derives utility from having children. A child is conceived out of the consent of his two parents, and is raised with resources contributed by both. For simplicity, we assume that they have identical preferences and endowment. Denote respectively by u and y each individual's utility function and endowment (endowment includes all types of resources needed to raise a child such as financial resources, time, attention, etc.). We assume that u is twice-continuously differentiable and strictly concave and increasing in the number of children. Let c be the price of a child, n_m the total number of children born to the man m and all his wives, and n_i the number of children born to wife w_i $(i = 1, ..., l)$. It follows that:

$$n_m = n_1 + ... + n_l \text{ and } cn_m = y + ly \tag{1}$$

Given that a child is conceived out of the consent of his two parents, it makes sense to assume that a man who has several wives decides how many children to give each wife. In fact, a wife cannot have more children than her husband wants to give her. Conversely, a husband cannot give any of his wives more children than the number she desires. But within our framework, we have assumed that man m and each of his wives have identical preferences, so that no wife desires more children than m. We shall therefore consider a unitary household model in which all incomes are pooled together and the husband, acting as a social planner, decides how many children (n_i) to give each wife w_i. [8] We assume that he allocates children

[7] This is equivalent to assuming that each parent derives utility from children as well as from other consumption goods, with resources being allocated in a "fixed" proportion between children and these other goods.

[8] Another way to model the fertility decision of each individual within our context is to assume that the husband and his wives play a non-cooperative game in which the strategy set of each wife is the set of positive real numbers $\mathbb{R}_+$, and the strategy set of the husband is the $l-$cartesian product of the set of positive real numbers $\mathbb{R}^l_+$ (each wife chooses the number of children she would like to have and the husband chooses the number of children he would like to have with each wife; and assuming wife i wants to have x_i children and the husband wants to have x^i children with her, then i will have $n_i = \min(x_i, x^i)$ children as the consent of both the husband and the wife is necessary for a child to be conceived). If we assume that the husband is equally altruistic to his wives in that he cares not only about his own payoff, but also about the payoffs of his wives, we can show that the solution of the social planner problem as we model it in this paper is a Nash equilibrium of the fertility game we just defined. In addition, that Nash equilibrium can be shown to be efficient. It follows that our social planner model is a realistic model of fertility decisions within our framework.

across his wives so as to maximize a social welfare function such as the following:

$$U(n_m, n_1, ..., n_l) = u(n_m) + u(n_1) + ... + u(n_l) \quad ^{9} \tag{2}$$

His maximization problem can be formulated as follows:

$$\begin{aligned} Maximize\ U(n_m, n_1, ..., n_l) &= u(n_m) + u(n_1) + ... + u(n_l) \\ \text{subject to} \qquad n_m &= n_1 + ... + n_l, \\ cn_m &= y + ly, \\ n_i &\geq 0, i = 1, ..., l \end{aligned} \tag{3}$$

It is easy to see that the solution of (3) is the egalitarian solution $n_i^* = n_w^* = \frac{y}{lc} + \frac{y}{c}$ for all $i = 1, ..., l$ and $n_m^* = \frac{y+ly}{c}$.[10] Interestingly, we note that the functional form of n_w^* shows that each woman receives the number of children corresponding to her own endowment plus her husband's endowment shared equally across all wives. These results lead to the following testable implications, which say that the number of children that a man has increases with the number of wives he has, but the number of children that each wife has decreases with the number of co-wives.

Proposition 1 *n_m^* is strictly increasing in l and n_w^* is strictly decreasing in l.*

Proof. The proof comes from the expression of n_m^* and n_w^* above. ■

We note that Proposition 1 implies that a woman in a monogamous relationship has more children than a woman in a polygynous relationship. However, a man in a monogamous relationship has less children than a man in a polygynous relationship.

3.3.2 Envy or children as a signal of prestige

We now introduce envy or "others' regarding preferences" in the model. This may arise in a context in which the number of children is a source of prestige to their parents, so that having more children than other parents in the society generates more utility. More formally, if we

[9] Note that our social welfare function is slightly different from traditional social welfare functions which do not incorporate the social planner's utility. In this respect, our social planner is not entirely "benevolent".

[10] The egalitarian solution arises because we assume that the husband marries all his wives simultaneously, or that the order in each he marries his wives is random. We could have assumed a sequential model in which the husband marries his wives in a fixed order as follows: he marries woman 1 in the first period, woman 2 in the second period, and so on, until he marries all his l wives. In each period t, the husband solves problem (3), maximizing the social welfare function $U(n_m, n_1, ..., n_t) = u(n_m) + u(n_1) + ... + u(n_t)$ under the assumption that his endowment y is equally split across the l periods in which he marries. The number of children that each wife produces after the l periods is the sum of children produced since marrying the husband. Solving this problem shows that higher-order wives will have more children, but the number of children that the husband will have will not differ from the number of children produced under the assumption that he marries his wives simultaneously. It follows that the relationship between polygyny and the "average" number of children for each woman is the same whether we assume a simultaneous model or a sequential model.

let n_{i_j} be the number of children born to an individual $i_j \in N$, and n_{-m} be the total number of children born to his/her neighbor, then the individual's utility is increasing in $n_{i_j} - \alpha n_{-m}$ where $\alpha > 0$ is the degree to which he/she envies his/her neighbor. In particular, if α tends to 0, there is little envy, a situation similar to our assumption in Section 3.3.1. We shall also assume that each individual derives utility from other consumption goods that we summarize into a single variable $x \in \mathbb{R}_+$. It follows that each individual's utility function is defined over the collection of bundles $(n_{i_j} - \alpha n_{-m}, x)$. For simplicity, we shall assume such a utility function to be additively separable, so that it can be written as:

$$u(n_{i_j} - \alpha n_{-m}) + v(x) \tag{4}$$

where each of the functions u and v is twice-continuously differentiable, strictly concave and increasing.

Following the same argument developed in the model without envy, we shall consider a unitary household model again where the husband, acting as a social planner, allocates children across his wives and the $x-$good across his wives and himself. If we let p be the price of the $x-$good, his maximization problem will now be:

$$\begin{aligned} Maximize\ U(n_m, n_1, ..., n_l, x_m, x_1, ..., x_l) &= u(n_m - \alpha n_{-m}) + v(x_m) + u(n_1 - \alpha n_{-m}) \\ &\quad +v(x_1) + ... + u(n_l - \alpha n_{-m}) + v(x_l) \\ \text{subject to} \qquad n_m &= n_1 + ... + n_l, \\ cn_m + p(x_m + x_1 + ... + x_l) &= y + ly, \\ n_i &\geq 0, i = 1, ..., l, \\ x_m &\geq 0, x_i \geq 0, i = 1, ..., l \end{aligned} \tag{5}$$

The following claims will be useful in the analysis of this maximization problem.

Claim 1 *U attains a maximum in the constraint set.*

Proof. It follows from the constraints that each $n_i \in [0, \frac{y+ly}{c}]$ and each $x_i \in [0, \frac{y+ly}{p}]$, $i = m, 1, 2, ..., l$. The constraint set therefore is $C = [0, \frac{y+ly}{c}]^{l+1} \times [0, \frac{y+ly}{p}]^{l+1}$, which is a closed and bounded subset of $\mathbb{R}^{2(l+1)}$. Hence, it follows from the Heine-Borel Theorem that C is compact. Given that U is a real-valued continuous function defined on a compact set, we conclude by the Bolzano-Weierstrass Theorem on the existence of extreme value that U attains a maximum in C. ■

Claim 2 *Let f be a real-valued continuous function defined on a bounded interval $I \subset \mathbb{R}$. If f is strictly concave and increasing, then the function defined by $g(x_1, ..., x_n) = f(x_1) + ... + f(x_n)$ attains a unique maximum $(x_1^*, ..., x_n^*)$ in I^n $(n > 1)$. Furthermore, $x_1^* = x_2^* = ... = x_n^*$.*

Proof. The proof is left to the reader. ■

Given that U is additively separable, following Bergstrom (2011), (4) can be split up into the following maximization problems:

$$\begin{aligned} & Maximize\ u(n_m - \alpha n_{-m}) \\ \text{subject to} \quad & cn_m = y_1 \end{aligned} \tag{6}$$

and

$$\begin{aligned} & Maximize\ u(n_1 - \alpha n_{-m}) + ... + u(n_l - \alpha n_{-m}) \\ \text{subject to} \quad & n_m = n_1 + ... + n_l, \\ & n_i \geq 0, i = 1, ..., l \end{aligned} \tag{7}$$

and

$$\begin{aligned} & Maximize\ v(x_m) + v(x_1) + ... + v(x_l) \\ \text{subject to} \quad & p(x_m + x_1 + ... + x_l) = y_2, \\ & x_m \geq 0, x_i \geq 0, i = 1, ..., l \end{aligned} \tag{8}$$

where $y_1 + y_2 = y + ly$. Here, income is spent on children (y_1) and other consumption goods (y_2). But unlike in Section 3.3.1, the allocation of income between these two types of goods is not fixed.

The solution of (6) is $n_m^* = \frac{y_1}{c}$. It follows from Claim 2 that the solution of (7) is $(n_1^*, ..., n_l^*)$ such that $n_1^* = n_2^* = ... = n_l^* = \frac{n_m^*}{l}$, and the solution of (8) is $(x_m^*, x_1^*, ..., x_l^*)$ such that $x_m^* = x_1^* = ... = x_l^*$

Since the egalitarian solution arises in equilibrium, suppose $n_i = n_w$ $(i = 1, ..., l)$, and $x_i = x$ $(i = m, 1, ..., l)$. Our maximization problem then becomes:

$$\begin{aligned} Maximize\ U(n_w, x) &= u(ln_w - \alpha n_{-m}) + lu(n_w - \alpha n_{-m}) + (l+1)v(x) \\ \text{subject to} \quad cln_w + p(l+1)x &= y + ly \\ n_w &\geq 0 \\ x &\geq 0 \end{aligned} \tag{9}$$

Claim 1 and Claim 2 ensure that a unique equilibrium exists. We distinguish three cases: (a) $n_w = 0$; (b) $x = 0$; (c) $n_w > 0$ and $x > 0$.

If $n_w = 0$, then $x^* = \frac{y+ly}{p(l+1)}$. If $x = 0$, then $n_w^* = \frac{y+ly}{cl}$, which corresponds to the previously analyzed situation in which children were the only good.

If $n_w > 0$ and $x > 0$, then from the equality constraint, we deduce $x = \frac{y+ly-cln_w}{p(l+1)}$, which implies that the social planner's problem will simply consist of maximizing:

$$U(n_w) = u(ln_w - \alpha n_{-m}) + lu(n_w - \alpha n_{-m}) + (l+1)v(\frac{y + ly - cln_w}{p(l+1)}) \tag{10}$$

or equivalently

$$U(n_m) = u(n_m - \alpha n_{-m}) + lu(\frac{n_m}{l} - \alpha n_{-m}) + (l+1)v(\frac{y + ly - cn_m}{p(l+1)}) \tag{11}$$

Both functions will be useful for the comparative statics analysis. The first order conditions for these two functions are respectively:

$$U'(n_w) = lu'(ln_w - \alpha n_{-m}) + lu'(n_w - \alpha n_{-m}) - \frac{cl}{p}v'(\frac{y + ly - cln_w}{p(l+1)}) = 0 \tag{12}$$

and

$$U'(n_m) = u'(n_m - \alpha n_{-m}) + u'(\frac{n_m}{l} - \alpha n_{-m}) - \frac{c}{p}v'(\frac{y + ly - cn_m}{p(l+1)}) = 0 \tag{13}$$

We derive testable implications. First, the number of children that a man has increases with the number of his wives, but the number of children that each wife has increases or decreases with the number of wives depending on the utility function.

Proposition 2 *n_m^* is strictly increasing in l. n_w^* may be strictly increasing or decreasing in l depending on the utility function.*

Proof. 1) We want to show that at $n_m = n_m^*$, $\frac{\partial n_m}{\partial l} > 0$. First compute $\frac{\partial n_m}{\partial l}$ by applying the Implicit Function Theorem to (13). Write:

$$U'(n_m) = u'(n_m - \alpha n_{-m}) + u'(\tfrac{n_m}{l} - \alpha n_{-m}) - \tfrac{c}{p}v'(\tfrac{y+ly-cn_m}{p(l+1)}) = f(n_m, l, n_{-m}).$$

We have:

$$\tfrac{\partial n_m}{\partial l} = -\tfrac{\partial f(n_m,l,n_{-m})}{\partial l} \times (\tfrac{\partial f(n_m,l,n_{-m})}{\partial n_m})^{-1}.$$

The reader can check that:

$$-\tfrac{\partial f(n_m,l,n_{-m})}{\partial l} = -(-\tfrac{n_m}{l^2}u''(\tfrac{n_m}{l} - \alpha n_{-m}) - c^2 n_m v''(\tfrac{(l+1)y-cn_m}{p(l+1)})).$$

It follows that $-\frac{\partial f(n_m,l,n_{-m})}{\partial l} < 0$ given that $u'' < 0$ and $v'' < 0$ by assumption.

Also, we have:

$$\tfrac{\partial f(n_m,l,n_{-m})}{\partial n_m} = u''(n_m - \alpha n_{-m}) + \tfrac{1}{l}u''(\tfrac{n_m}{l} - \alpha n_{-m}) + \tfrac{c^2}{p^2(l+1)}v''(\tfrac{(l+1)y-cn_m}{p(l+1)}) < 0.$$

This implies that $(\frac{\partial f(n_m,l,n_{-m})}{\partial n_m})^{-1} < 0$. Since $\frac{\partial n_m}{\partial l}$ is the product of two negative numbers, it is positive.

2) Let us prove that at $n_w = n_w^*$, the sign of $\frac{\partial n_w}{\partial l}$ is ambiguous. Compute $\frac{\partial n_w}{\partial l}$ by applying the Implicit Function Theorem to (12). Write:

$$U'(n_w) = lu'(ln_w - \alpha n_{-m}) + lu'(n_w - \alpha n_{-m}) - \tfrac{cl}{p}v'(\tfrac{y+ly-cln_w}{p(l+1)}) = g(n_w, l, n_{-m}).$$

We have:

$$\tfrac{\partial n_w}{\partial l} = -\tfrac{\partial g(n_w,l,n_{-m})}{\partial l} \times (\tfrac{\partial g(n_w,l,n_{-m})}{\partial n_w})^{-1}.$$

The reader can check that:

$$-\frac{\partial g(n_w,l,n_{-m})}{\partial l} = -(ln_w u''(ln_w - \alpha n_{-m}) + u'(ln_w - \alpha n_{-m}) + u'(n_w - \alpha n_{-m}) - \frac{c}{p}v'(\frac{(l+1)y - cln_w}{p(l+1)}) - \frac{c^2 ln_w}{p^2(l+1)^2}v''(\frac{(l+1)y - cln_w}{p(l+1)})).$$

Given that $u' > 0$ and $u'' < 0$, the sign of $-\frac{\partial g(n_w,l,n_{-m})}{\partial l}$ is clearly ambiguous. It could be positive or negative. However, we have the following:

$$\frac{\partial g(n_w,l,n_{-m})}{\partial n_w} = (l^2 u''(ln_w - \alpha n_{-m}) + lu''(n_w - \alpha n_{-m}) + \frac{cl}{p^2(l+1)}v''(\frac{(l+1)y - cln_w}{p(l+1)}) < 0.$$

So if $-\frac{\partial g(n_w,l,n_{-m})}{\partial l} > 0$, then $\frac{\partial n_w}{\partial l} < 0$, and if $-\frac{\partial g(n_w,l,n_{-m})}{\partial l} < 0$, then $\frac{\partial n_w}{\partial l} > 0$. ■

We also analyze the impact of a neighbor's fertility on an individual's own fertility. We find that an individual's number of children is positively affected by the number of children his neighbor has, which is a *contagion effect* of fertility.

Proposition 3 *n_m^* is strictly increasing in n_{-m}.*

Proof. It suffices to prove that $\frac{\partial n_m^*}{\partial n_{-m}} > 0$. First write Equation (13) as:

$$U'(n_m) = u'(n_m - \alpha n_{-m}) + u'(\frac{n_m}{l} - \alpha n_{-m}) - \frac{c}{p}v'(\frac{y + ly - cn_m}{p(l+1)}) = f(n_m, l, n_{-m}).$$

Apply to this equation the Implicit Function Theorem. We have:

$$\frac{\partial n_m}{\partial n_{-m}} = -\frac{\partial f(n_m,l,n_{-m})}{\partial n_{-m}} \times (\frac{\partial f(n_m,l,n_{-m})}{\partial n_m})^{-1}.$$

The reader can check that:

$$-\frac{\partial f(n_m,l,n_{-m})}{\partial n_{-m}} = -\alpha[(-u''(n_m - \alpha n_{-m}) - u''(\frac{n_m}{l} - \alpha n_{-m})] < 0.$$

Also, we have:

$$\frac{\partial f(n_m,l,n_{-m})}{\partial n_m} = u''(n_m - \alpha n_{-m}) + \frac{1}{l}u''(\frac{n_m}{l} - \alpha n_{-m}) + \frac{c^2}{p^2(l+1)}v''(\frac{(l+1)y - cn_m}{p(l+1)}) < 0.$$

It follows that $(\frac{\partial f(n_m,l,n_{-m})}{\partial n_m})^{-1} < 0$. We conclude that $\frac{\partial n_m}{\partial n_{-m}} > 0$, which holds at $n_m = n_m^*$. ■

Not surprisingly, we note from the expression of $-\frac{\partial f(n_m,l,n_{-m})}{\partial n_{-m}}$ in the proof that as the degree of envy (α) tends to 0, the marginal effect of an individual's neighbor fertility on his own fertility tends to 0 as well. So fertility is only as contagious as envy is strong.

As a corollary of Proposition 3, a monogamous individual in a functioning polygynous culture has more children than a monogamous individual in a monogamous culture.

Corollary 3 *Any individual, regardless of whether he/she is involved in a monogamous or a polygynous relationship, has more children if he/she lives in a functioning polygynous culture than if he/she lives in a monogamous culture.*

Proof. The proof follows from the fact that in a functioning polygynous culture, there is at least one man who has several wives, and who by Proposition 2 has more children than he would have had in a monogamous culture. An individual in a polygynous culture is therefore exposed to the fertility behavior of such a polygynist, which by Proposition 3 has a positive effect on his/her own fertility. ■

3.4 Aggregate fertility in a polygynous versus a monogamous culture

In this section, we investigate the effect of matrimonial culture on the total number of children in a society. Our analysis draws on the findings of the previous sections. We will distinguish two situations, namely one in which the number of children that a woman has decreases with the number of wives her husband has, and one in which the opposite holds. From the analysis conducted in previous sections, we know that the first situation occurs when children are the only consumption good, or under certain conditions, when children bring prestige to their parents. We will see that in such a situation, the effect of a polygynous culture on the aggregate number of children is ambiguous.

Let $(s_i^*)_{i \in M}$ be the demand for women by the men in a hierarchical mating economy. We know that $M = M_1 \cup M_2$ and $s_i = 0$ if $i \in M_2$. We have the following result.

Proposition 4 *Assume that* $\frac{\partial n_w^*}{\partial l} < 0$.

1) If $\sum_{i \in M_1} s_i^* < |W|$, *then the total number of children is greater in a polygynous culture than in a monogamous culture. The inequality is strict if* $s_i^* > 1$ *for some man* $m_i \in M_1$.

2) If $\sum_{i \in M_1} s_i^* \geq |W|$, *then the total number of children may be lower in a polygynous culture than in a monogamous culture.*

Proof. 1) If $\sum_{i \in M_1} s_i^* < |W|$, meaning that the aggregate demand for women by the men who may get married is smaller than the total number of women, then obviously, each man in M_1 will obtain his optimal number of women in the unique equilibrium that exists in the economy. Since each man in M_1 has at least one woman, by Propositions 1 and 2, each such man will have at least the number of children he would have had in a monogamous culture, implying that the total number of children is greater in a polygynous than in a monogamous culture. Assume that $s_i^* > 1$ for some man $m_i \in M_1$. By Propositions 1 and 2, given that m_i has more than one wife, he will have strictly more children than he would have had in a monogamous culture, which implies strict inequality when we compare the aggregate number of children under the two regimes.

2) If $\sum_{i \in M_1} s_i^* \geq |W|$, all women will get married in a polygynous culture, but some men in M_1 may remain unmatched. Let us show by a simple example that the total number of children may be lower in a polygynous culture than in a monogamous culture. Consider a hierarchical mating economy that has 4 men m_1, m_2, m_3, and m_4 and 4 women w_1, w_2, w_3, and w_4, where $(s_1^*, s_2^*, s_3^*, s_4^*) = (2, 2, 1, 1)$ and $M_1 = M$ (each man may marry). Suppose that preferences for the number of children are such that a monogamous man gets 3 children and a man who has two wives gets 4 children, with each wife having 2 children (note that this assumption is consistent with $\frac{\partial n_m^*}{\partial l} < 0$). Under monogamy, the unique equilibrium matching is the one in which each man m_i matches with woman w_i. In this case, each couple has 3 children, and

thus the total number of children is 12. Under polygyny, the unique equilibrium matching is one in which m_1 is matched with w_1 and w_2, m_2 is matched with w_3 and w_4, and m_3 and m_4 are unmatched. In this case, m_1 and m_2 will have 4 children each, and m_3 and m_4 will have no children, yielding a total of 8 children. We conclude that in this particular example, the total number of children is smaller under polygyny than under monogamy, despite the fact that a polygynist has strictly more children than a monogamist at the individual level. Note, however, that if $(s_1^*, s_2^*, s_3^*, s_4^*)$ were $(2, 1, 1, 0)$, the other assumptions remaining unchanged, the total number of children would have been 10 under polygyny and 9 under monogamy, and the conclusion therefore would have been different. ■

We note that the condition under which polygyny positively affects aggregate fertility is more likely to be empirically valid, as there exist single women even when polygyny is allowed.

In the second situation where the number of children that a woman has increases with the number of wives her husband has, we find that the total number of children is greater in a polygynous culture than in a monogamous culture.

Proposition 5 *Assume that* $\frac{\partial n_w^*}{\partial l} > 0$*. Then, the total number of children is greater in a polygynous culture than in a monogamous culture. The inequality is strict if* $s_i^* > 1$ *for some man* $m_i \in M_1$*.*

Proof. By Corollary 1, we know that the number of women who get married is greater in a polygynous than in a monogamous culture. Since $\frac{\partial n_w^*}{\partial l} > 0$ by assumption, under polygyny, each such woman has at least the number of children she would have got under monogamy, which implies that the total number of children is greater in a polygynous than in a monogamous culture. If one such woman shares her husband with at least one woman (that is, $s_i^* > 1$ for some man $m_i \in M_1$), by the assumption that $\frac{\partial n_w^*}{\partial l} > 0$, she will have strictly more children than she would have had in a monogamous culture, which yields the strict inequality. ■

4 Testable and tested predictions

The model developed in the preceding sections has yielded a rich set of testable predictions that we summarize below:

1. Beautiful women are more likely to be married (this follows from Theorem 1).

2. Beautiful women are more likely to be married to polygynous men, or to be cheated if polygyny is not allowed (Corollary 2).

3. Beautiful women are more likely to have at least one child–the *extensive margin*–(this follows immediately from the fact that (a) female beauty increases marital success as implied by Theorem 1, and (b) the demand from children is greater within marriage).

4. Beauty has no clear effect on the number of children produced by a woman– the i*ntensive margin*– as female beauty increases the likelihood of marrying a polygynist, but being married to a polygynist has an ambiguous effect on the number of children produced (see prediction 8 below).

5. Higher-status men are more likely to be polygynous (Theorem 1, Theorem 2).

6. Polygyny prevalence increases the likelihood of marriage for women (Corollary 1).

7. A polygynous man has more children than a monogamous man (Proposition 1, Proposition 2).

8. Being married to a polygynous man has an ambiguous effect on the number of children produced by a woman: the effect may be negative or positive, or there might be no effect (Proposition 2).

9. Women, regardless of whether they are involved in a monogamous or polygynous relationship, have more children as the prevalence of polygyny in their region of residence increases, which is the *contagious effect* of polygyny on fertility (Corollary 3).

10. Polygyny prevalence has a positive effect on aggregate fertility (Proposition 4, Proposition 5). According to proposition 4, the effect may be negative if the aggregate demand for women is greater than the supply of women, something that is usually not observed in reality.

Our testable predictions can be divided into two sets. The first set ((1)-(5)) reveals the effect of female and male characteristics such as beauty and wealth on marital and reproductive outcomes. The second set ((6)-(10)) reveals the multi-faceted effects of polygyny and polygyny prevalence on individual and aggregate fertility.

Clearly, these predictions are too many to be rigorously tested in only one paper. We therefore only focus our efforts on a limited number of predictions, which are those that have not been sufficiently tested in the literature. Also, because of data limitations, we will only be able to perform a descriptive analysis for most of the tested predictions, showing only correlations. In the first part of the empirical section, we will test the effect of female beauty on marital and reproductive outcomes ((1)-(4)). The second part will test the micro-level mechanism through which polygyny prevalence positively affects aggregate fertility. According to the theory, polygyny prevalence increases aggregate fertility throught two main channels: (1) by increasing the number of marriages (prediction 6); and (2) by trigerring fertility contagion (prediction 9). Because our study is the first to theoretically document this second channel through which polygyny prevalence affects fertility, we will also try to empirically establish its causality. All these tests will be carried out using household data from multiple sub-Saharan African countries.

5 Empirical test of the model

5.1 Data

The data is taken from the DHS surveys and covers 32 countries from sub-Saharan Africa.[11] As marriage and fertility outcomes both vary with time and age, we use several waves of surveys for each country whenever possible (see Appendix Table A) to disentangle those two dimensions.[12]

Polygyny is only illegal in six countries[13]. But legal changes in polygyny regulations can hardly be considered as exogenous events. They tend to follow the evolutions of customs rather than the contrary. Indeed several countries encountered severe difficulties in passing laws to ban polygyny (for instance, Uganda) or in enforcing them (Senegal).[14] Moreover, polygyny is common, although less widespread, in countries where it is unlawful, such as Burundi or Madagascar.

Table 1 presents average statistics over countries in our sample. First, at around three children born per woman, ranging from 3.9 in Niger to 1.9 in South Africa, average fertility remains high throughout the continent.

The percentage of women involved in a relationship, either through a legal union or an informal cohabition, is also rather elevated, ranging from 38% in Namibia to 86% in Niger.

Polygyny appears to be very frequent, and is more widespread in western Africa than elsewhere on the continent. 43% and 45% of women in Senegal and Benin respectively, are married to polygynous men, versus less than 20% in Eastern Africa.

Interestingly, the desire for children is acknowledged to be very high, with many women still giving unrealistic answers to the question regarding the ideal number of children they would like to have. On average, women declare wanting more than seven children, but this number even exceeds ten in six countries. In spite of a declining fertility, preferences for children remain strong.

---

[11] The Demographic and Health Survey (DHS) used in this study were carried out by : the Statistical and Health Services (Ghana), the Institut National de la Statistique (Cote d'Ivoire), the Institut National de la Statistique (Benin), the Ministère du Plan et de l'Aménagement du Territoire (Cameroon, 1991), the Bureau Central des Recensements et Etudes de Population (Cameroon, 1998), the Institut National de la Statistique (Cameroon, 2004), the Centre National de Recherches sur l'Environment (Madagascar, 1992), the Institut National de la Statistique (Madagscar, 1997, 2003, 2008), the National Statistical Office (Malawi), the Federal Office of Statistics (Nigeria, 1990), the National Population Commission (Nigeria, 1999, 2003, 2008), the Office National de la Population (Rwanda, 1992, 2000), the Ministry of Economics (Rwanda, 2005), the Ministère des Finances (Senegal, 1992, 1997), the SERDHA (Senegal, 1999), the Ministère de la Santé, CRDH (Senegal, 2005, 2006), the National Bureau of Statistics (Tanzania), the Bureau of Statistics (Uganda) and the Central Statistical Office (Zimbabwe).

[12] There are 25 countries with more than one survey available and 19 with at least three surveys.

[13] See annex A for details.

[14] In Senegal, as in many other countries, men are supposed to choose a "polygynous" or "monogamous" status when they marry for the first time. However, it is common for men who opted for monogamy during their youth to later marry a second wife. This law is difficult to enforce as the first spouse may have to choose between polygyny and a divorce.

Female education is low, as many women surveyed between the ages of 15 and 49 did not benefit from the push toward universal primary education of the early 2000s. Average years of schooling exceeds six years in only six out of 32 countries. Finally, infant mortality rates are still very high, ranging from 37 per thousand in Zimbabwe to 85 per thousand in Mozambique.

[Table 1]

5.2 Beauty, marriage, polygyny, and fertility

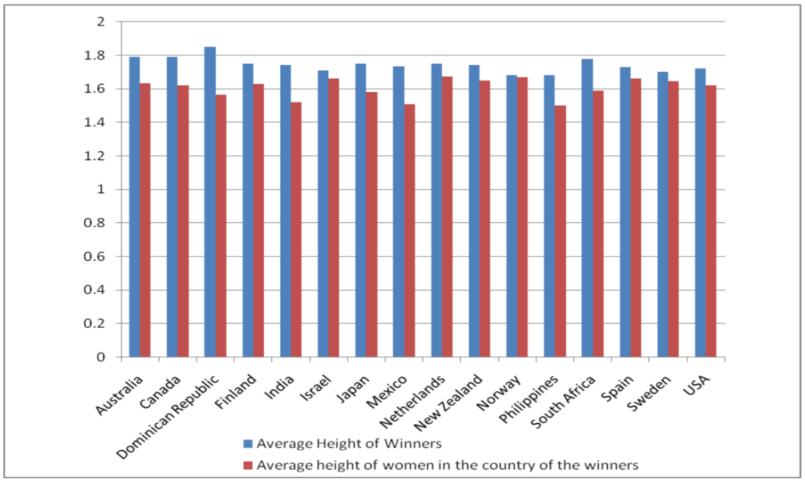
We test the propositions that more beautiful women are more likely: (i) to be married (prediction 1); (ii) to be married to polygynists (prediction 2); and (iii) to have at least to have at least one child (prediction 3). We also test the effect of beauty on number of children conditional on fecundity (prediction 4). Prior to testing these relationships, it is appropriate to discuss how beauty is measured.

5.2.1 Measuring beauty

The physical attractiveness of women is an important factor in determining their desirability as partners. As explained by Pawlowski (2003), sexual selection is a well established evolutionary process based on preferences for specific traits in one sex by members of the other sex. It is important in the evolution of morphological traits, and several sexually dimorphic traits in humans, such as facial hair and facial shape. In general, however, the appreciation of beauty varies across the world. Some components of external beauty such as low waist-to-hip ratio (Singh, 1995) and clear complexion (Symons, 1979) are agreed upon across most cultures. However, other attributes such as weight and skin tone vary across cultures and time frames. In renaissance art, most women are depicted as large women with pale skin. Both of those features were indicators of wealth and good health. In contrast, most of the women displayed in media as symbols of beauty today are thin and have tanned skin.

In present day "media", height and thinness are the standard for beauty. Models across the world are much taller than average. While walking the runway, heights are exaggerated even further with high heels. Most mannequins displaying women's attire in stores tower over customers and beauty pageants are dominated by tall and thin women. One of the biggest international beauty contests is Miss Universe, where beauty contest winners from several countries compete for the international title. We calculate that the average height of the titleholders from 1980-2011 is 1.75 m, and find that all the winners are taller than the average women of their nationality (see Figure 6 for selected countries). As people are widely exposed to and influenced by media today, taller women are regarded as more beautiful and in turn more desirable.

Figure 6: Winners of Miss Universe are taller than the average women



It follows that several measures of beauty, including waist-to-hip ratio, skin complexion, height, weight, body mass index (calculated as weight in kilograms divided by the square of height in meters), have been used in the literature.[15] Of these measures, height, weight and the BMI are the most popular, perhaps because of their availability in most datasets (e.g., Chiappori, Oreffice, and Quintana-Domeque 2012). The DHS data used for our analysis have information on these anthropometric indicators. Therefore, we use all the three indicators as proxies for beauty. However, only height appears to produce results that are consistent with our model. In fact, due to the cross-sectional nature of the DHS datasets, height is a more appropriate, although imperfect, measure of physical attractiveness because it is more stable over time than weight and BMI after a certain age. Indeed, since our goal is partly to study the effect of beauty on marriage outcomes, weight and BMI measured at the survey are not appropriate measures of beauty because the weight and BMI of a woman who is married at the survey may be very different than when she got married, and will therefore fail to explain her "past" marriage outcome. But such a woman most likely has the same height as when she got married, and so, "current" height as a measure of beauty can explain her "past" marriage outcome. The other advantage of using height is that it is determined by genetic, feotal and early childhood conditions (Martorell and Habicht 1986; Schultz 2002; Eveleth and Tanner 1976), and so should largely be viewed as preceding or being exogenous to the marital and reproductive outcomes we want to predict.

5.2.2 The empirical test

The value of height translates into marital success. Table 2 shows that taller women are more likely to be married (Column (I)). They are also more likely to marry polygynous men (Column (II)). These findings confirm that female height is valued by men.

[15] Importantly, the multiplicity of measures seems to indicate that there is no perfect measure for beauty. As our theoretical analysis acknowledges, the appreciation of beauty might also be subjective.

With respect to fertility, taller women are more likely to have at least one child (Column (III)); but conditional on being fecund, taller women do not have more children than shorter women (Column (IV)).

These effects are robust to the control of age, year of survey, place of residence, education, religion, and country fixed-effects.

Some of our findings complement other studies that have found a positive relationship between stature and reproductive success (Nettle (2002) , Powlowski (2003)). Also, Smits (2012) finds a positive correlation between women's height and marital success. This study shows that taller than average women in India are more likely to marry, get higher educated husbands with better jobs and are less likely to marry at a very young age or to lose their husbands through divorce or premature death.

[Table 2]

5.3 Polygyny prevalence and aggregate fertility: The micro-level mechanism

In this section, we test the micro-level mechanism through which polygyny prevalence affects aggregate fertility, as implied by prediction 10. As shown by Figure 7, regional polygyny prevalence positively affects the average number of children, consistent with Propositions 4 and 5.

Figure 7: Partial correlation between regional polygyny prevalence and fertility

According to our theoretical model, polygyny prevalence positively affects aggregate fertility through two channels: (1) by increasing the number of marriages; and (2) by triggering fertility contagion. We will test of these channels, while insisting on the second one because of its novelty, as noted earlier.

5.3.1 Effects of polygyny prevalence on marriage

We test the proposition that the practice of polygyny increases the likelihood of a woman getting married (prediction 6). We perform this test using a probit model, following equation (14). Countries in the DHS are divided into regions, indexed by j. Our pooled sample has 324 regions and gathers women who were born between 1941 and 1996. As marriage outcomes might have changed over time, generational effects must be disentangled from other social effects. To do so, we split the sample by year of birth into five categories: 1940-1963, 1964-1971, 1972-1977, 1978-1983, 1984-1996. The cut off years have been chosen to obtain sub-samples of similar size. By crossing regions j and generations k, one obtains 1,274 different strata from which meaningful averages can be computed, such as, for instance, the prevalence of polygyny. The average number of individuals belonging to a generation k and living in the region j is about 800, which is sufficient to ensure that average statistics are representative at this level. Breaking up regional averages by generation is necessary as marriage choices are likely to be influenced by neighboring women of similar age. Importantly, regressions estimated by using variables averaged across regions and years of the survey give similar results.

We assume that the probability of marriage m^i for a woman i depends on a vector of individual characteristics X^i, region/cohort characteristics $Y^{j,k}$, and the region/cohort prevalence of polygyny $\bar{p}^{j,k}$. Controls include age, fecundity, religion, height, a year trend, and average level of education, which may capture the fact that women are more free to refuse (early) marriage in a society where they are collectively empowered by education.

$$m^i = \Phi\big(X^i\beta_m + \bar{p}^{j,k}\zeta_n + Y^{j,k}\theta_m\big) \tag{14}$$

Results are reported in Table 3, columns (I) to (III). We note that women are more likely to be involved in a union in areas where polygyny is more frequent. Moreover the effect of polygyny is very significant.

The analysis is robust to alternative measures of marital outcomes. Columns (IV) to (VI) show that polygyny prevalence decreases the probability of divorce and the probability of remaining single after having been formerly married. It therefore appears that the practice of polygyny stabilizes marriage and significantly increases the probability of remarriage after the loss of a husband.

[Table 3]

5.3.2 The effect of polygyny on individual-level female fertility

In this section, we test the effects of being married to a polygynist on the number of children produced by a woman (prediction 8). The test is performed by restricting the sample to women currently involved in a relationship. We control for several potential confounding variables including the overall duration of marriage, whether a woman was married more than once, whether or not she is fecund, religion, country and urban/rural place of residence. We also control for the projected infant mortality rate at the individual level. This is because the infant mortality rate (the number of child deaths before one year of age per 1000 births) is hypothesized to increase fertility as parents produce more children in order to insure themselves against the loss of a baby.[16]

We use OLS regressions to estimate the effect of being married to a polygynist on the number of children (equation 15). In equation 15, $n_m^{i,j,k}$ denotes the number of children born to a married woman i, who has characteristics X^i, belongs to generation k, and resides in country/region j; p^i is a binary indicator for whether woman i is married to a polygynous man, and a^t a yearly trend:

$$n^{i,j,k} = p^i\gamma + X^i\beta + a^t + c^{j,k} + \varepsilon^i \tag{15}$$

Estimations results are reported in Table 4 :

[Table 4]

We find that the effect of being married to a polygynist on number of children varies null to negative depending on the controls (columns (IV)-(VI)). In particular, it becomes significantly negative once the duration of marriage and country fixed effects are controlled for (column (IV)). This correlation is very robust to the inclusion of other controls such individual child mortality (column (V)) or region and year fixed effects (column (VI)). Although the estimates are not shown, the duration of the union is found to increase fertility, while women who married more than once have on average about 0.6 children less. The average infant mortality in the region increases fertility in all specifications. Furthermore, the Bayesian estimate of the probability of infant death at the individual level is also positively correlated with fertility.

The negative impact of polygyny on female fertility suggests that the taste for reproduction versus consumption is not too strong in sub-Saharan Africa.

[16]In our sample, the infant mortality rate is very high, reaching 73.8 per thousand in Malawi and 69.3 per thousand in Tanzania. However, infant mortality is likely to also depend on individual factors. An obvious measure of infant mortality the *actual* rate of infant death among the children of the women whose fertility we try to study. However, such a measure is strongly endogenous. Because the number of children born is a discrete variable and is small, the *actual* mortality rate is a very uncertain measure (especially for women without children or with a small number of children) of the *theoretical* probability of death of a woman's young children. We use a Bayesian method to build individual mortality rate (see the appendix for details). The modeling relies on the assumption that the probability of death of a child does not depend on her rank in the family.

5.3.3 Fertility contagion: The effect of polygyny prevalence on individual-level fertility

In this section, we test the prediction fertility is contagious. More precisely, we show that women, regardless of whether they are involved in a monogamous or a polygynous marriage, have more children as the prevalence of polygyny in their region of residence increases (prediction 9).

A preliminary analysis We estimate the following model:

$$n^{i,j,k} = p^i\gamma + X^i\beta + \bar{p}^{j,k}\zeta + Y^{j,k}\theta + a^t + \varepsilon^i \quad (16)$$

The variables p^i, X^i, $\bar{p}^{j,k}$ and $Y^{j,k}$ are interpreted as in the previous equations. Our main parameter of interest is ζ, which measures the effect of region/cohort polygyny prevalence on individual-level fertility. We estimate Equation (16) using OLS. Results are reported in Table 5:

[Table 5]

A woman produces more children if polygyny is more prevalent in her region of residence and cohort. The effect is high and statistically significant for all women (Column I), including those involved in a monogamous union (Columns III). Controlling for all other variables, a woman in a monogamous union produces 0.68 more children if she lives in a highly polygynous society than if she lives in a monogamous society.

Clearly, our estimate of the effect of polygyny prevalence on the number of children produced by a woman is likely to suffer from issues of endogeneity. A key confounding factor is health, which might determine both the level of polygyny and fertility. We therefore control for several measures of female health at the region/cohort level. More precisely, we control for child mortality rate and the female adult survival rate at the regional level.[17] The adult mortality rate has a negative impact on fertility, because women dying prematurely have less time available to bear children, but this impact is never statistically significant. On the contrary, children mortality rate has a positive impact on fertility, as households ensure themselves against the loss of children by producing more children. Therefore, introducing the adult mortality rate allows us to capture not only the general sanitary conditions (which are already embedded into the regional children's mortality rate), but also features of the health and social systems which directly affect women's health.

Second, we control for the average share of women declared infecund at the regional level. This captures other local or contextual particularities (such as genetics, pollution and health systems) that may affect conditions in which reproduction and pregnancies take place. The

[17] This statistics is computed as the percentage of respondent's sibling who were alive at the time of interview, after controlling for the siblings' age and age squared and the year of interview using a probit model.

share of infecund women has a strong negative and statistically significant effect on the number of children born.

Third, we compute the share of women aged 18-49 at the regional level who are neither pregnant nor with an infant and whose last periods occurred more than three months ago. This indicator captures fertility issues linked to genetic or chronic diseases and malnutrition. It has a strong a significant negative impact on fertility.

Overall, the positive correlation between polygyny prevalence and number of children is highly robust to the inclusion of a wide range of pertinent health indicators. As a consequence, this correlation is unlikely to be due to underlying connections between health status, fertility and polygyny.

Interestingly, we also control for the effect of being married to a polygynist, finding that women married to polygynists tend to have less children than those involved in a monogamous relationship. The coefficient (-0.10) is remarkably close to previous estimates in Table 4.

We therefore conclude that while being married to a polygynist has a negative effect on female fertility (which is consistent with Proposition 1), living in a region with a high a prevalence of polygyny positively affects fertility, our contagious effect (Corollary 3). We note that being married to a polygynist is a "choice variable", whereas polygyny prevalence is not (an individual does not choose whether his/her neighbor gets involved in a polygynous relationship). It follows that polygyny prevalence is a more exogenous variable than the choice to marry a polygynist, which suggests that the effect of the former variable is more likely to be causal. What makes our inference of causality from the effect of polygyny prevalence on individual-level female fertility even more convincing is the fact that polygyny prevalence also positively affects the fertility of women involved in a monogamous relationship. Polygyny prevalence is clearly exogenous for these women since they obviously do not contribute to it.

Instrumental variable In this section, we strengthen our claim of a causal effect of polygyny prevalence on individual-level fertility by using an instrumental variable suggested by our theoretical model. According to the theory, female beauty increases the likelihood of entering into a polygynous union but does not have a clear impact on the number of children. In Section 4.2, we validated these predictions by showing that taller women are more likely to be married to polygynous men. But conditional on being fecund, they do not have more children than shorter women. These findings suggest that height may only affect fertility through its indirect impact on both marriage success and polygyny. Therefore, height can be used as an instrument for polygyny when estimating the effect of polygyny on fertility. Indeed, if taller women are more valued as spouses and are more likely to marry polygynous men, then a population with a large proportion of tall women, all other things being equal, should experience a higher frequency of marriages.

We estimate the effect of regional polygyny prevalence on the number of children born to a woman in a relationship, finding a positive and statistically significant effect (Table 6, Column

(I)). This effect is robust to the inclusion of regional averages of age, education, religion, infant mortality, female adult mortality and infecundity, and country fixed effects.

We use the regional average height as an instrument for regional polygyny prevalence. Average height positively affects polygyny prevalence, with the effect being robust to the inclusion of all the variables mentioned above. The system is identified as the number of instrument matches the number of endogenous variables. When instrumented for by average height, polygyny prevalence increases the number of children by 3.8 (Table 6, Column (II)), which is statistically positive but not statistically different from the OLS-estimated effect (Table 6, Column (I)). Furthermore, an endogeneity test (not shown) shows that OLS estimates are consistent (P-value is 0.08). Restricting the sample to women in monogamous unions provides similar findings. However, in that case, an endogeneity test indicates that OLS estimates are not consistent (P-value is 0.03). Therefore it is likely that an unbiased estimate of the impact of polygyny on fertility is actually higher than the 0.70 multiplier estimated using OLS.

Notice that this effect cannot be viewed as reflecting the notion that taller women are healthier on average as many direct measures of health status - such as (i) absence of period, (ii) infecundity, (iii) female adult survival rates, (iv) infant mortality, and (v) the overall health system effectiveness embedded into country fixed effects - are already taken into account in the regressions.

[Table 6]

Moreover, although height may be correlated with health status at the individual level, at the aggregate level, variation in average height depends much more heavily on genetic variations (Schultz 2002), which are independent of health status. In fact in the developed world where polygyny is non-existent, cross country variations in average height are not positively correlated with fertility. To verify this assumption and take advantage of cross-country variations in polygyny, one can run the same regressions without the country fixed effects. Also, and as already noted, we control for infecundity.

In results not shown, we also use average height and the legal status of polygyny in a country as instruments for polygyny prevalence. We distinguish between polygyny being recognized as a legal union, polygyny being tolerated as a custom union, and polygyny being banned. We find that cross-country variations in both average height and legal status of polygyny are good predictors of polygyny prevalence. We also find that polygyny prevalence has a positive ans statistically significant effect on the number of children produced by a woman.

5.4 Robustness checks

This section examines whether the documented effect of polygyny on fertility is robust to cultural traits favoring gender differentiation, male domination, and fertility.

We make the underlying assumption that male-dominant societies tend to confine women to a reproductive role. In such societies, spouses and thus children are seen as signs of wealth, and men tend to accumulate both to increase their social status. If this assumption is valid, variables related to gender discrimination and male domination should explain both the levels of fertility and the practice of polygyny. These variables capture social norms and customs. We therefore compute indicators averaged at the regional level. By controlling for these variables, we will be able to check the robustness of the estimates of polygyny prevalence on individual-level female fertility. Particularly, if the effect of polygyny prevalence becomes insignificant, the correlation between that variable and fertility only reflects the local culture and cannot be interpreted as causal.

As polygyny is correlated with lower age at first marriage, higher fertility and lower levels of schooling for women, this suggests these variables can be used as proxies for a conservative culture, and they might indicate that tasks and roles for men and women within the household and the society are greatly polarized. The DHS provide rich information on these variables, which allows us to capture cultural values and behaviors. We use different indicators to measure cultural beliefs and behaviors:

- **Tolerance for domestic violence**: In the DHS, women are asked if they believe a husband is justified to beat his wife if she refuses to have sex. The tolerance of domestic violence from the women's side is a signal of male domination.

- **Bias toward male children**: A way to measure bias for men in the society is to look at preferences regarding the gender of children. In the DHS, women are asked about the "ideal" number of boys ($\#^*_{boys}$) and girls ($\#^*_{girls}$) they would like to have. This allows us to compute an indicator of gender biasas in equation (17):

$$bias_{boys} = \frac{\#^*_{boys} - \#^*_{girls}}{\#^*_{boys} + \#^*_{girls}} \tag{17}$$

  When there is no bias, $biais_{boys}$ is equal to zero. The measure $biais_{boys}$ is positive when there is a bias toward boys and negative when there is a bias toward girls.

- **Control of money**: The money of the household may be managed primarily by men or women. If men exclusively manage the household's finances, this signals a lack of trust in women or a lack of female independence.

- **Duration of breast-feeding**: Longer breast-feeding periods are often associated with longer durations of postpartum amenorrhoea[18] and abstinence, which may favor polygyny as well.

- **Family planning**: Women in the DHS are also asked several questions about whether they discuss family planning with their husband, whether they approve family planning[19], whether their husband approve family planning, and whether they already had a terminated pregnancy.[20]

These variables are averaged at the regional level and by year of survey. Their partial correlations are reported in Table 7. These variables are good candidates with which to measure gender bias and describe a conservative culture. On the one hand, tolerance for violence against wives, bias toward male children, family planning approval and terminated pregnancies are strongly or moderately correlated with fertility, marriages and the prevalence of polygyny. On the other hand, the control of money by men, breastfeeding and abstinence after delivery are correlated with polygyny.

[Table 7]

To test whether the correlation between polygyny and fertility is due to culture, we add the aforementioned variables in the fertility regression (equation 16). Results are reported in Table 8.

[Table 8]

We find that although all the added variables simultaneously explain polygyny, fertility and marriage, they do not explain the correlation between polygyny prevalence and number of children born to a woman. It follows that this correlation is unlikely to be purely an artefact of local cultural particularities.

6 Conclusion

In this paper, we propose a simple network theory of a mating economy that has implications for marital success, the characteristics of men and women who enter into a polygynous marriage, and for how polygyny affects individual and aggregate level fertility. We find that beautiful women are more likely to be married, which implies that they are more likely to have a child. When polygyny is allowed, these women are more likely to be married to high status

[18] Absence of menstrual period, often induced by a recent pregnancy and breastfeeding.

[19] In practice approval rates for family planning by men and women are highly correlated at the regional level (0.90), therefore, we only use men's attitudes towards family planning as a control variable, as it is more highly correlated with our variables of interest.

[20] This is a rough indicator of abortion as it counts all pregnancies that were not completed, whether naturally or not.

men, who naturally attract other women. Therefore, female beauty increases the chance of entering into a polygynous relationship.

Being married to a polygynous man negatively affects fertility as long as the preference for children relative to other consumption goods is not too strong. However, at the societal level, the practice of polygyny increases aggregate fertility by increasing the number of marriages and by positively affecting individual-level fertility through a contagion effect. Our analysis is the first that reconciles the apparently paradoxical effects of polygyny on fertility at the individual and aggregate levels. We have tested and validated the key predictions of the model using household surveys from several countries.

References

Becker, G.S. (1960): "An Economic Analysis of Fertility," in G. S. Becker (ed.), Demographic and Economic Change in Developed Countries. Princeton University Press, 209–231.

Becker, G. S. (1974): "A Theory of Marriage: Part II," *Journal of Political Economy* 82(2), S11-S26.

Becker, G.S. (1981): A Treatise on the Family. Harvard University Press, Cambridge MA.

Becker, G.S., Murphy, K.M., and Tamura, R. (1990): "Human Capital, Fertility, and Economic Growth," *Journal of Political Economy* 98(5), S12-S37.

Bergstrom, T.C. (1994): "On the Economics of Polygyny," Department of Economics, University of California Santa Barbara, Paper 1994A.

Case, A., and Paxson, C. (2008): "Stature and Status: Height, Ability, and Labor Market Outcomes," *Journal of Political Economy* 116(3), 499-532.

Chesnais, J.C. (1992): The Demographic Transition: Stages, Patterns and Economic Implications. Clarendon Press, Oxford.

Chiappori, P., Oreffice, S., and Quintana-Domeque, C. (2012): "Fatter Attraction: Anthropometric and Socioeconomic Matching on the Marriage Market," *Journal of Political Economy* 120(4), 659 - 695.

Choo, E., and Siow, A. (2006): "Who Marries Whom and Why," *Journal of Political Economy* 114(1), 172–201.

De la Croix, D. and M. Doepke (2003): "Inequality and Growth: Why Differential Fertility Matters," *American Economic Review* 93(4), 1091-1113.

Doepke, M. (2004): "Accounting for Fertility Decline During the Transition to Growth," *Journal of Economic Growth* 9(3), 347-383.

Doepke, M. (2005): "Child Mortality and Fertility Decline: Does the Barro-Becker Model Fit the Facts?," *Journal of Population Economics* 18(2), 337–366.

Eveleth, P.B., and Tanner, J.M. (1976): Worldwide Variation in Human Growth. Cambridge: Cambridge University Press.

Fenske, J. (2013): "African Polygamy: Past and Present," Mimeo.

Fernández-Villaverde, J. (2001): "Was Malthus Right? Economic Growth and Population Dynamics," Working Paper, Department of Economics, University of Pennsylvania.

Gale, D., and Shapley, L. S. (1962): "College Admissions and the Stability of Marriage," *American Mathematical Monthly* 69(1), 9-15

Galor, O., and Weil, D.N. (1996): "The Gender Gap, Fertility, and Growth," *American Economic Review* 86(3), 374-387.

Galor, O. and Weil, D.N. (1999): "From Malthusian Stagnation to Modern Growth," *American Economic Review* 89(2), 150-154.

Galor, O. and Weil, D.N. (2000): "Population, Technology, and Growth: From

Malthusian Stagnation to the Demographic Transition and Beyond," *American Economic Review* 90(4), 806-828.

Galor, O. (2005): "The Demographic Transition and the Emergence of Sustained Economic Growth," *Journal of European Economic Association* 3(2-3), 494-504.

Garenne, M., and van de Walle, E. (1989): "Polygyny and Fertility among the Sereer of Senegal," *Population Studies* 43(2), 267-283.

Grossbard, A. (1978): "Towards a Marriage between Economics and Anthropology and a General Theory of Marriage." *American Economic Review* 68(2), 33-37.

Jacoby, H.G. (1995): "The Economics of Polygyny in Sub-Saharan Africa: Female Productivity and the Demand for Wives in Côte d'Ivoire," *Journal of Political Economy* 103 (5), 938-971.

Jones, L. E., and Tertilt, M. (2006): "An Economic History of Fertility in the US: 1826–1960," NBER Working Paper No. 12796.

Kalemli-Ozcan, S. (2002): "Does the Mortality Decline Promote Economic Growth?," *Journal of Economic Growth* 7(4), 411–439.

Lambert, S., and Behaghel, L. (2011): "Polygyny and Intergenerational Transmission of Education in Senegal," Paris School of Economics, mimeo.

Martorell, R., and Habicht, J. (1986): "Growth in Early Childhood in Developing Countries," in Falkner, F., and Tanner, J. M. (eds), Human Growth, Vol. 3. New York: Plenum Press.

Muhsam, H.V. (1956): "The fertility of polygynous marriages," *Population Studies* 10, pp. 3-16

Murphy, T.E. (2009): "Old Habits Die Hard (Sometimes): What Can Département Heterogeneity Tell Us About the French Fertility Decline?," Mimeo.

Nerlove, M. (1974): "Households and Economy: Toward a New Theory of Population and Economic growth," *Journal of Political Economy* 82(2), 200-218.

Nettle D. (2002): "Women's Height, Reproductive Success and the Evolution of Sexual Dimorphism in Modern Humans," *Proceedings of Royal Society B* 269, 1919-1923.

Pawlowski, B. (2003): "Variable Preferences for Sexual Dimorphism in Height as a Strategy for Increasing the Pool of Potential Partners in Humans," *Proceedings of Royal Society B* 270, 709-712.

Pebley, A., and Mbugua, W. (1989): "Polygyny and Fertility in Sub-Saharan Africa," in Lesthaeghe, R. (ed.), Reproduction and Social-Organization in Sub-Saharan Africa. Berkeley, University of California Press, 338-364.

Pencavel, J. (1998): "Assortative Mating by Schooling and the Work Behavior of Wives and Husbands,"*American Economic Review* 88(2), 326–329.

Pongou, R. (2009): "An Economic Theory of Fidelity in Network Formation," Mimeo.

Pongou, R., and Serrano, R. (2009): "A Dynamic Theory of Fidelity Networks with an Application to the Spread of HIV/AIDS," Working paper 2009-2, Brown University.

Pongou, R., and Serrano, R. (2013): "Fidelity Networks and Long-Run Trends in HIV/AIDS Gender Gaps," *American Economic Review* 103(3), 298-302.

Schoellman, T., and Tertilt, M. (2006): "Marriage Laws and Growth in Sub-saharan Africa," *American Economic Review* 96 (2), 295-298.

Schultz, P. T. (2002): "Wage Gains Associated with Height as a Form of Health Human Capital," *American Economic Review* 92(2), 349-353.

Singh, D., and Luis, S. (1995): "Ethnic and Gender Consensus for Role of Waist-to-Hip Ratio on Judgment of Women's Attractiveness," *Human Nature* 6(1), 51-65.

Smits, J., and Monden, C.W.S. (2012): "Taller Indian Women are More Successful at the Marriage Market," *American Journal of Human Biology* 24 (4), 473-478.

Symons, D. (1979): The Evolution of Human Sexuality. Oxford, Oxford University Press.

Tertilt, M. (2005): "Polygyny, Fertility, and Savings," *Journal of Political Economy* 113(6), 1341-1371.

Tertilt, M. (2006): "Polygyny, Women's Rights, and Development," *Journal of the European Economic Association* 4 (2-3), 523-530.

Timaeus, I.M., and Reynar, A. (1998): "Polygynists and their Wives in Sub-Saharan Africa: An Analysis of Five Demographics and Health Surveys," *Population Studies* 52(2), 145-162.

UNICEF (2005): Early Marriage: A Harmful Practice. A Statistical Exploration. New York, UNICEF.

Appendix: Building the individual infant mortality rate

A.1) Assumption and framework

We assume that an infant's probability of death is the sum of a function $\mu(\bullet)$ of observable individual characteristics X and an idiosyncratic factor z. That is:

$$\mu = \mu(X) + z \tag{B.1}$$

Let n be the total number of children and k the number of deaths. The observed mortality rate m, can only take discrete values which depend on n:

$$m = \frac{k}{n} \in \left\{ \frac{p}{n} : \; p = 1, ..., n \right\} \tag{B.2}$$

The law of probability of m thus depends on n and μ as follows:

$$\mathcal{P}\left(\frac{k}{n}|n, \mu\right) = \binom{n}{k} (\mu)^k (1-\mu)^{n-k} \tag{B.3}$$

Using the Bayes formula, we can express μ as a function of m:

$$\mathcal{P}\left(\mu|n, m\right) = \frac{\mathcal{P}\left(m|n, \mu\right) \times \mathcal{P}(\mu)}{\int P(m|n, \mu) \times \mathcal{P}(\mu)} \tag{B.4}$$

To compute this probability, we need to define a prior distribution for z.

A.2) Using beta distributions to model priors

Using a uniform distribution for the prior distribution leads to unrealistic posterior distributions for small numbers of children n. We therefore retain a beta distribution $\mu \sim \mathcal{B}(\alpha, \beta)$, and denoting Γ the Gamma function[21], one has:

$$\mathcal{P}(\mu) = g(\mu) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} (\mu)^{\alpha-1}(1-\mu)^{\beta-1} \tag{B.5}$$

α and β parameters can be set to replicate the expectancy E and the variance V of any prior distribution of μ:

$$\alpha = \frac{E^2(1-E)}{V} - E \; , \; \beta = \frac{\alpha(1-E)}{E} \tag{B.6}$$

The posterior probability of μ, given k and n, remains a beta distribution:

$$\mathcal{P}(\mu|k, n) = \frac{(\mu)^{k+\alpha-1}(1-\mu)^{n-k+\beta-1}}{\int_0^1 x^{k+\alpha-1}(1-x)^{n-k+\beta-1}dx} \Rightarrow \mu \sim \mathcal{B}(k+\alpha, n-k+\beta) \tag{B.7}$$

[21] $\Gamma(z) = \int_0^\infty t^{z-1}e^{-t}dt$, $\Gamma(n) = (n-1)!$ if n is an integer.

Therefore, we can deduce the posterior expectancy of the sought probability μ using the proprieties of the Beta distribution:

$$E\Big[\mu|k,n\Big] = E\Big[\mathcal{B}(k+\alpha, n-k+\beta)\Big] = \frac{k+\alpha}{n+\alpha+\beta} \tag{B.8}$$

The posterior expectancy can be rewritten as a linear combination of the prior expectancy $E^0[\mu]$ and the observable mortality rate m. The weights depend of the expectancy and the variance of the prior distribution and the number of children.

$$E\Big[\mu|m,n\Big] = m\frac{n}{n+w_{E,V}} + E^0[\mu]\frac{w_{E,V}}{n+w_{E,V}} \ , \ w_{E,V} = \frac{E^0(1-E^0)}{V^0} - 1 \tag{B.9}$$

As expected, the Bayesian estimates relies more on the prior for the women with few children. Also, the more accurate the prior distribution is (i.e., the smaller the variance V^0), the more the prior distribution matters for the posterior estimates.

A.3) Empirical estimation of the individual probability of infant mortality

We start by calculating the average mortality rate for babies born in a period t for each region and area (rural or urban) r, $mort_t^r$. We distinguish the period 1960-1979[22] from each of the five year periods between 1980 and 2010. The indicator $mort_t^r$ is calculated as the ratio of the total number of infants dead to the total number of children born in a given area and period. It captures external factors (i.e., factors not related to parents) which affect infant mortality. We control for it in a probit model to estimate E^0. We regress, for each country, the *actual* mortality rate m on variables listed in equation (B.10) below, where t_{p1} is the year of the woman's first pregnancy, a_{p1} and a_{p1}^2 are respectively the age of the woman's first pregnancy and its quadratic, and h is the woman's years of schooling .

$$\mathcal{P}(m) = \Phi\left(\mu_0 + \mu^t t_{p1} + \mu^a a_{p1} + \mu^{aa} a_{p1}^2 + \mu^h h + \mu^r mort_t^r\right) \tag{B.10}$$

The expectancy E^0 is therefore:

$$E^0 \equiv \mathcal{P}\Big(m^i|t_{p1}, a_{p1}, h^i, mort_t^r\Big) \tag{B.11}$$

It is difficult to estimate V^0 for such a regression. We will assume therefore that:

$$V^0 \equiv (E^0)^2 \tag{B.12}$$

[22] Because all DHS surveys only focus on women less than 50, only a few children are born before 1980.

Table 1: Averages of the main variables by country (computed for women 15-49 years old)

	# children	Involved	Polygyny	Ideal # children	Schooling	Mortality	# obs.
Burkina Faso	3.4	79.6	49.3	8.5	1.3	71.4	18,831
Benin	3.2	75.1	45.1	7.0	2.1	54.3	29,504
Burundi⋆	2.7	57.7	7.3	5.5	3.1	43.4	9,389
Congo, Dem.⋆	3.0	66.3	28.8	8.2	5.3	66.0	9,995
Centrafrique	2.9	69.4	28.5	10.7	2.2	55.0	5,884
Congo⋆	2.3	55.9	16.1	8.0	7.7	37.0	19,464
Cote d'Ivoire	2.6	58.5	31.0	6.0	3.3	48.1	2,825
Cameroon	2.9	68.5	32.9	9.3	5.2	53.0	2,0028
Ethopia⋆	3.0	63.4	12.1	8.0	2.1	57.1	45,952
Gabon	2.5	54.1	22.0	7.3	6.9	41.1	6,183
Ghana	2.6	63.8	23.3	5.5	6.0	42.7	2,0012
Guinea	3.4	80.7	52.9⋆	7.5	1.5	70.1	14,707
Kenya	2.9	60.2	17.2	5.1	7.0	44.6	32,060
Liberia	3.2	64.0	21.8	6.6	3.8	70.2	15,428
Madagascar	3.0	65.6	5.5⋆	6.8	4.1	50.6	38,644
Mali	3.8	84.3	42.1	10.6	1.3	73.1	37,136
Malawi	3.1	71.4	17.1	5.6	4.1	71.9	29,767
Mozambique	3.3	71.3	26.4	7.2	2.7	85.0	32,409
Nigeria	3.0	69.8	35.0	11.1	5.3	62.6	59,596
Niger	3.9	85.9	36.0	11.7	0.8	83.4	15,726
Namibia	2.1	37.9	23.8	4.6	7.5	34.0	21,980
Rwanda⋆	2.8	50.7	12.3	5.2	3.7	56.0	28,293
Sierra Leone	3.0	74.9	39.4	6.3	2.6	81.3	7,374
Senegal	2.7	68.3	43.3	10.1	2.5	42.8	48,946
Swaziland	2.3	41.3	33.9	2.7	8.1	51.1	4,987
Chad	3.6	77.5	39.2	12.3	1.0	73.2	13,539
Togo	2.9	67.9	42.8	6.6	2.6	51.4	8,569
Tanzania	2.9	64.0	23.4	7.1	5.1	58.8	48,034
Uganda	3.5	67.2	30.9	6.3	4.5	63.5	22,847
South Africa	1.9	43.3	11.2	3.1	8.7	41.3	11,735
Zambia	3.1	61.8	16.4	6.4	5.8	66.2	29,885
Zimbabwe	2.4	59.9	16.6	4.3	7.5	37.2	20,942

"Involved" is the percentage of women involved in a relationship, whether it is a legal union or not.

"Polygyny" is the percentage of women involved with a man who has other wives, whether it is legal or not.

⋆ denotes countries where polygyny is prohibited.

"Schooling" is the average years of schooling.

"Mortality" is the number of children (over 1,000) who died before reaching the age of one.

Table 2: The effect of height on marriage, polygyny, sex and fertility

	(I) Probit	(II) Probit	(III) Probit	(IV) OLS
	Involved in a relationship	In polygynous union	Has at least one child	# children born*
Height	0.25*** (5.0)	0.14*** (4.0)	0.13*** (6.8)	0.2 (1.2)
Controls	Yes	Yes	Yes	Yes
Adjusted R^2	0.19	0.12	0.17	0.21
# observations	447,043	310,389	430147	352,339

* Analysis restricted to fecund women.

T-statistics or Z-statistics are in parentheses. *,** ,*** indicate significance at the 5%, 1% and 0.1% levels.

Controls: Age, year of survey, years of schooling, rural, religion, country fixed effects.

Standard deviations are computed by clustering observations by country.

Table 3: Probit effects of regional polygyny prevalence on nuptiality

	(I)	(II)	(III)	(IV)	(V)	(VI)
	Is not single			Is not divorced/widow		
Polygyny^{j,k}	0.38^{**} (2.9)	0.34^{**} (2.9)	0.16^{*} (2.5)	-0.17^{***} 5.4)	-0.18^{***} (6.2)	-0.07^{*} (2.3)
Education^{j,k}	-0.003 (0.4)	-0.004 (0.6)	-0.01^{**} (2.9)	0.001 (0.9)	0.001 (0.7)	-0.001 (1.7)
Religion^{j,k}	NO	YES	YES	NO	YES	YES
Country	NO	NO	YES	NO	NO	YES
# observations	437,553	437,553	437,553	333,665	333,665	333,665
pseudo R^2	0.17	0.17	0.20	0.07	0.07	0.10
Sample	All women			Excluding never married women.		

T-statistics are in parentheses. *,**,*** indicate significance at the 5%, 1% and 0.1% levels.

Additional controls: Age, age^2, years of schooling, rural area, year trend, height,

a dummy for fecundity, religion dummies.

Standard deviations are computed by clustering observations by country.

The superscripts ^{j,k} indicate that the variable is computed at the region/generation level.

Table 4: OLS effect of being married to a polygynist on number of children

	(I)	(II)	(III)	(IV)	(V)	(VI)
Married to a polygynist	-0.01 (0.4)	0.02 (0.9)	-0.05 (1.8)	-0.06^{*} (3.1)	-0.08^{**} (3.6)	-0.10^{***} (4.2)
Union duration	No	No	Yes	Yes	Yes	Yes
Number of unions	No	No	Yes	Yes	Yes	Yes
Indiv. child mortality	No	No	No	No	Yes	Yes
Fixed effects	None	Country	None	Country	Country	Regions & Years
# observations	461,301	461,301	453,439	453,439	439,910	438,205
Adjusted R^2	0.52	0.53	0.57	0.58	0.61	0.60

T-statistics are in parentheses. *,**,*** indicate significance at the 5%, 1% and 0.1% levels.

Additional controls: Age, age^2, years of schooling, rural, year trend, average infant mortality in the region at the age of first birth, and religion.

Standard deviations are computed by clustering observations by country.

Table 5 : OLS effect of regional polygyny prevalence on number of children (contagion)						
	(I)	(II)	(III)	(IV)	(V)	(VI)
Married to a polygynist	-0.10^{***} (9.9)	-0.10^{***} (9.9)	-0.10^{***} (10.6)	-	-	-
Polygyny^{j,k}	0.71^{***} (4.4)	0.69^{***} (4.3)	0.47^{**} (2.7)	0.68^{***} (4.4)	0.68^{***} (4.2)	0.49^{**} (2.7)
Infecund^{j,k}	No	Yes	Yes	No	Yes	Yes
Amenorrhea^{j,k}	No	No	Yes	No	No	Yes
# obs.	353,151	353,151	349,266	254,116	254,116	254,116
adjusted R^2	0.61	0.62	0.61	0.64	0.64	0.64
Sample	All women in a relationship			Monogamous women		

T-statistics are in parentheses. *,**,*** indicate significance at the 5%, 1% and 0.1% level.

Additional controls: Age, age^2, years of schooling, rural, year trend, marriage duration,

a dummy for being ever married more than once, country fixed effects, individual-level infant mortality,

religion dummies, religion shares (region level), women's regional survival rate.

Standard deviations are computed by clustering observations at the region/generation level.

The superscripts ^{j,k} indicate that the variable is computed at the region/generation level.

Table 6: OLS and IV effect of regional polygyny prevalence on number of children				
	(I)	(II)	(III)	(IV)
	OLS	IV	OLS	IV
Married to a polygynist	-0.10^{***} (10.5)	-0.18^{***} (3.6)	-	-
Polygyny^{j,k}	0.77^{***} (5.3)	3.59^{*} (1.9)	0.86^{***} (5.3)	3.57^{*} (2.3)
Children mortality^{j,k}	10.80^{***} (13.0)	11.41^{***} (13.3)	9.28^{***} (11.6)	10.06^{***} (11.9)
Female survival rate^{j,k}	0.27 (0.7)	-0.02 (0.2)	0.24 (0.7)	-0.06 (0.1)
Fecundity^{j,k}	1.01^{*} (2.3)	1.78 (3.0)	0.63 (1.3)	1.55^{***} (2.7)
Amenorrhea^{j,k}	-0.73 (1.4)	-0.59 (1.0)	-0.76 (1.5)	-0.59 (1.0)
Sample	All women in a relationship		Monogamous women	
R^2	0.61	0.60	0.63	0.65
# observations	427,222	422,445	305,882	301,573

T-statistics are parentheses. *,**,*** indicate significance at the 5%, 1% and 0.1% levels.

Additional controls: Age, age^2, years of schooling, rural, year trend, marriage duration, a dummy for being ever married more than once, country fixed effects, individual infant mortality, religion dummies (individual), religion shares (region level), years of schooling (region level), generation fixed effects

Instruments for *polygyny*^{j,k}: all variables and average height at the region/generation level.

Standard deviations are computed by clustering observations at the region/generation level.

The superscripts ^{j,k} indicate that the variable is computed at the region/generation level.

Table 7: Partial correlations of number of children, marriage, and polygyny with cultural variables at the regional level

	# children	Married (%)	Polygyny (%)
Tolerance for beating	0.56	0.50	0.40
Bias toward boys	0.27	0.34	0.33
Money control	−0.07	−0.14	−0.43
Male family planning approval	−0.40	−0.48	−0.57
Family planning is discussed	−0.51	−0.60	−0.66
Termination	0.25	0.24	0.25
Breastfeeding	0.05	−0.01	−0.11
Abstinence	−0.08	0.01	0.25
Amenorrhea	0.24	0.16	0.02

Table 8: Effects of polygyny prevalence and gender bias on number of children					
	Dependent Variable: Number of children				
Polygyny^{j,k}	0.71^{***} (4.3)	0.68^{**} (2.9)	0.96^{***} (4.6)	0.73^{***} (3.3)	0.71^{***} (3.3)
Tolerance for beating ^{j,k}	-	0.42^{***} (3.3)	-	-	0.57^{***} (3.4)
Bias toward boys^{j,k}	-	0.78 (1.5)	-	-	-
Money control^{j,k}	-	0.12 (0.9)	-	-	-
Breast-feeding^{j,k}	-	-	-0.03^{***} (4.0)	-	-0.02 (1.7)
Abstinence^{j,k}	-	-	-0.06^{***} (9.6)	-	-0.07^{***} (8.6)
Amenorrhea^{j,k}	-	-	-0.04^{**} (2.8)	-	-0.05^{**} (2.9)
Family planning approval^{j,k}	-	-	-	-0.04 (0.2)	-
Family planning discussion^{j,k}	-	-	-	0.29^{**} (2.4)	-
Termination^{j,k}	-	-	-	0.27 (0.8)	-
Adjusted R^2	0.62	0.63	0.67	0.62	0.68
# observations	353,151	246,939	276,593	156,166	197,550

T-statistics are in parentheses brackets. *,**,*** indicate significance at the 5%, 1% and 0.1% levels.

Additional controls: Age, age^2, years of schooling (individual and region/generation level), rural, year trend, a dummy for being married to a polygynist, marriage duration, a dummy for being ever married more than once, infant mortality (individual and region/generation level), religion dummies (individual and region/generation level), adult mortality (region/generation level), country fixed effects.

The superscripts ^{j,k} indicate that the variable is computed at the region/generation level.

Table A: DHS surveys used						
Countries	Polygyny status	DHS II	DHS III	DHS IV	DHS V	DHS VI
Benin	Abolished (2004)		1996	2001	2006	
Burkina-Faso	Legal	1993		2003		
Burundi	Abolished (1993)		1996	2001	2006	
Cameroon	Legal	1991	1998	2004		
Central African R.	Legal		1994			
Chad	Legal		1997	2004		
Congo	Legal				2005, 2009	
Congo dem.	Unlawful				2007	
Cote d'Ivoire	Abolished (1964)		1994, 1998		2005	
Ethiopia	Unlawful			1992	1997	2003
Gabon	Legal			2000		
Ghana	Legal		1993	1998, 2003	2008	
Guinea	Legal			1999	2005	
Kenya	Legal		1993, 1998	2003	2009	
Lesotho	Legal				2004	2009
Liberia	Legal				2007, 2009	2011
Madgascar	Unlawful	1992	1997	2003		
Malawi	Legalized (2004)	1992		2000, 2004	2008	
Mali	Legal		1996	2001	2006	
Mozambique	Legal		1997	2003	2009	
Namibia	Legal	1992		2000	2007	
Niger	Legal	1992			2006	
Nigeria	Legal	1990		1999, 2003	2008	
Rwanda	Unlawful	1992		2000	2005	
Senegal	Legal	1992	1997	2005		
Sierra Leone	Legal				2008	
South Africa	Legal		1998			
Tanzania	Legal	1991	1996	1999, 2004	2007	
Togo	Legal		1998			
Uganda	Legal		1995	2000	2006	
Zambia	Legal	1992	1996	2002	2007	
Zimbabwe	Legal		1994	1999	2005	